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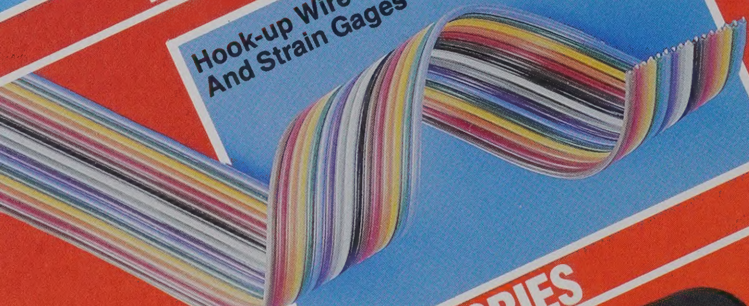
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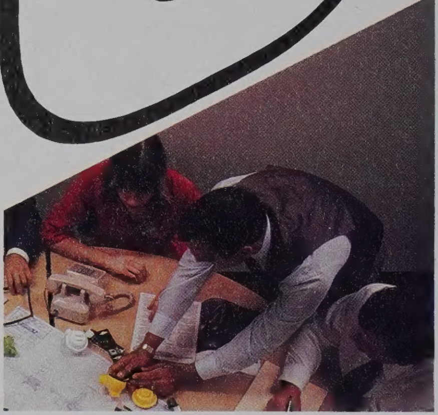

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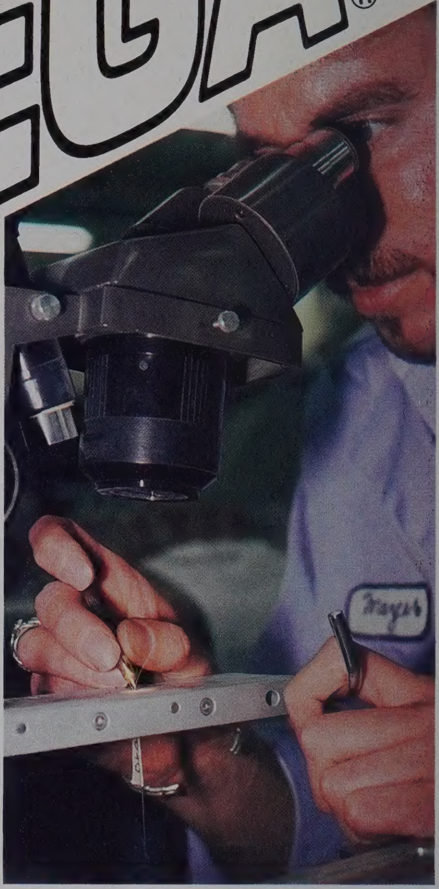

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A compendium of Technical Articles, charts and conversion tables plus Technical Reference books for use by engineers and scientists working in the Pressure Measurement and Control field.

A

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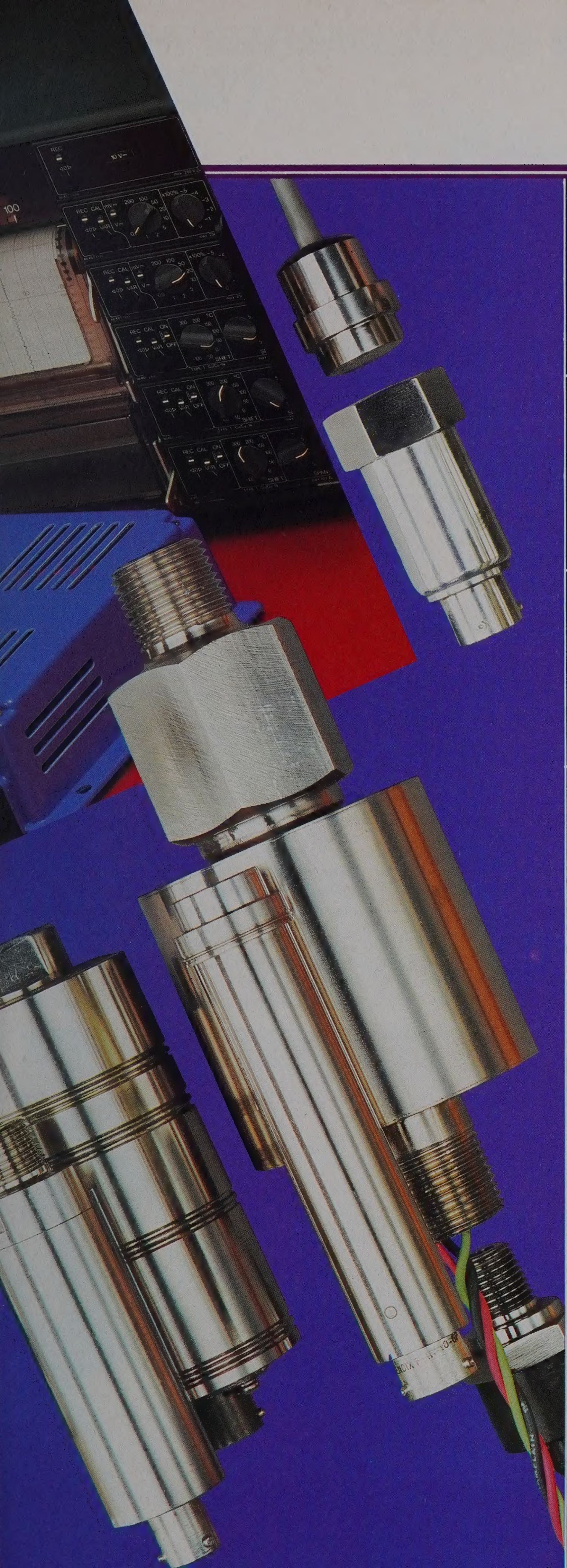

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PRESSURE REFERENCE SECTION
GLOSSARY

Absolute pressure transducer: A transducer which measures pressure in relation to zero pressure (a vacuum on one side of the diaphragm).

Accuracy: The total of all deviations from a specified straight line. Usually the sum of nonlinearity, repeatability, and hysteresis is expressed as a percent of full scale output.

Ambient conditions: The conditions around the transducer (pressure, temperature, etc.)

Ambient pressure: The pressure of the medium surrounding the transducer.

Amplifier: A device which draws power from a source other than the input signal and which produces as an output an enlarged reproduction of the essential features of its input.

Analog output: A voltage or current signal that is a continuous function of the measured parameter.

Best straight line: A line midway between two parallel straight lines closest together and enclosing all output vs. pressure values.

Breakdown voltage rating: The dc or ac voltage which can be applied across insulation portions of a transducer without arcing or conduction above a specific current value.

Bridge resistance: See Input impedance and Output impedance.

Burst pressure: The maximum pressure applied to a transducer sensing element or case without causing leakage.

Calibration: A test during which known process values are applied to the transducer and corresponding output readings are recorded under specified conditions.

Calibration curve: A graphic representation of the calibration record.

Calibration cycle: Calibration in ascending and descending directions.

Compensation: An addition of specific materials or devices to counteract a known error.

Dead volume: The volume of the pressure port of a transducer at room temperature and ambient barometric pressure.

Diaphragm: The sensing element consisting of a membrane which is deformed by the pressure differential applied across it.

Digital output: An output signal which represents the size of an input in the form of a series of discrete quantities.

Differential transducer: A transducer designed to accept two independent sources simultaneously. The output is proportional to the difference between the two sources.

Drift: An undesired change in output over a period of time which is not a function of the measurand.

Duty cycle: The pulse width times the frequency.

Dynamic calibration: Calibration in which the input varies over a specific length of time and the output is recorded vs. time.

End points: The end points of a full scale calibration curve.

Environmental conditions: All conditions in which a transducer may be exposed during shipping, storage, handling, and operation.

Error: The difference between the value indicated by the transducer and the true value of the measurand being sensed. Usually expressed in percent of full scale output.

Error band: The allowable deviations of output from a specific reference norm. Usually expressed as a percentage of full scale.

Excitation: The external application of electrical voltage current applied to a transducer for normal operation.

Flow: Flow or travel of liquids or gases in connection with pressure sensing devices.

Frequency-modulated output: A transducer output which is obtained in the form of a deviation from a center frequency, where the deviation is proportional to the applied stimulus.

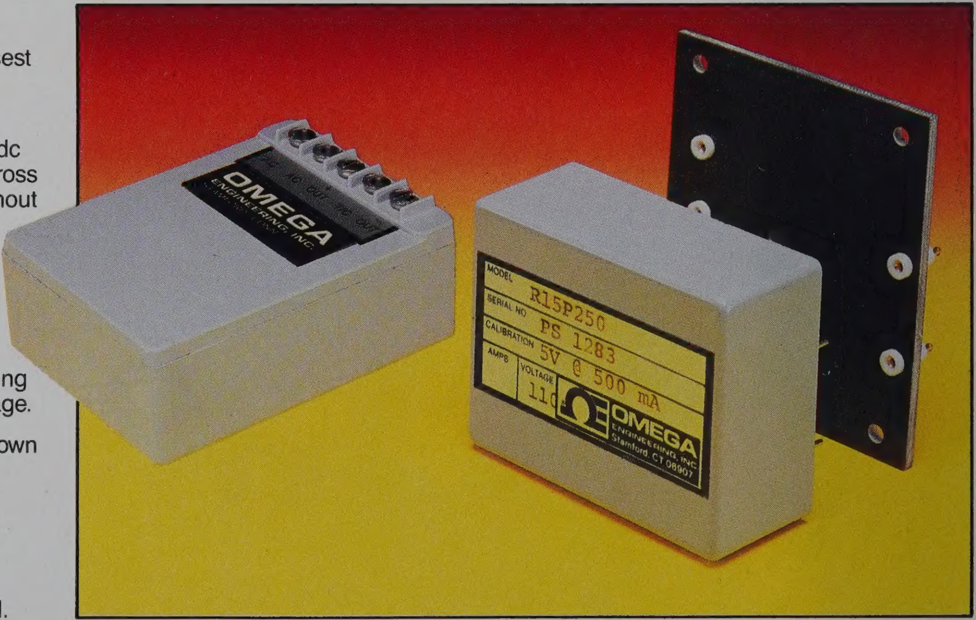
Frequency, natural: The frequency of free (not forced) oscillations of the sensing element of a fully assembled transducer.

Frequency output: An output in the form of frequency which varies as a function of the applied measurand.

Full bridge: A Wheatstone bridge configuration utilizing four active elements or strain gages.

Full scale output: The algebraic difference between the minimum output and maximum output.

Gage factor: A measure of the ratio of the relative change of resistance to the relative change in length of a piezoresistive strain gage.



PRESSURE REFERENCE SECTION
GLOSSARY

Gage length: The distance between two points where the measurement of strain occurs.

Gage pressure transducer: A transducer which measures pressure in relation to the ambient pressure.

Half bridge: Two active elements or strain gages.

Hooke's Law: Defines the basis for the measurement of mechanical stresses via the strain measurement. The gradient of Hooke's line is defined by the ratio of which is equivalent to the Modulus of Elasticity E (Young's Modulus).

Hysteresis: The difference in output when the pressure value is first approached with increasing pressure and then with decreasing pressure. Expressed in percent of full scale during any one calibration cycle.

Input impedance: The resistance measured across the excitation terminals of a transducer.

Insulation resistance: The resistance measured between two insulated points on a transducer when a specific dc voltage is applied at room temperature.

Leakage rate: The maximum rate at which a fluid is permitted or determined to leak through a seal. The type of fluid, the differential pressure across the seal, the direction of leakage, and the location of the seal must be specified.

Least-squares line: The straight line for which the sum of the squares of the residuals (deviations) is minimized.

Life cycle: The minimum number of pressure cycles the transducer can endure and still remain within a specified tolerance.

Linearity: The closeness of a calibration curve to a specified straight line. Linearity is expressed as the maximum deviation of any calibration point on a specified straight line during any one calibration cycle.

Linearity (end point): Linearity referred to a straight line between end points.

Load impedance: The impedance presented to the output terminals of a transducer by the associated external circuitry.

Maximum Elongation: The strain value where a deviation of more than ±5% occurs with respect to the mean characteristic (diagram of resistance change vs strain).

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Maximum excitation: The maximum value of excitation voltage or current that can be applied to the transducer at room conditions without causing damage or performance degradation beyond specified tolerances.

Measurand: A physical quantity, property, or condition which is measured.

Mechanical hysteresis: The difference of the indication with increasing and decreasing strain loading, at identical strain values of the specimen.

Mounting error: The error resultant from installing the transducer, both electrical and mechanical.

Normal (axial) stress: The force per unit area on a given plane within a body

$$\alpha = F/A$$

Null: A condition, such as balance which results in a minimum absolute value of output.

Output: The electrical signal which is produced by an applied input to the transducer.

Output impedance: The resistance as measured on the output terminals of a pressure transducer.

Output noise: The RMS, peak-to-peak (as specified) ac component of a transducer's dc output in the absence of a measurand variation.

Piezoresistance: Resistance that changes with stress.

Poisson Ratio: The ratio between the strain of expansion in the direction of force and the strain of contraction perpendicular to that force $\nu = -E_t/E_1$.

Principal Axes: The axes of maximum and minimum normal stress.

Proof pressure: The specified pressure which may be applied to the sensing element of a transducer without causing a permanent change in the output characteristics.

PSIA: Pounds per square inch absolute. Pressure referenced to a vacuum.

PSID: Pounds per square inch differential. Pressure difference between two points.

PSIG: Pounds per square inch gage. Pressure referenced to ambient air pressure.

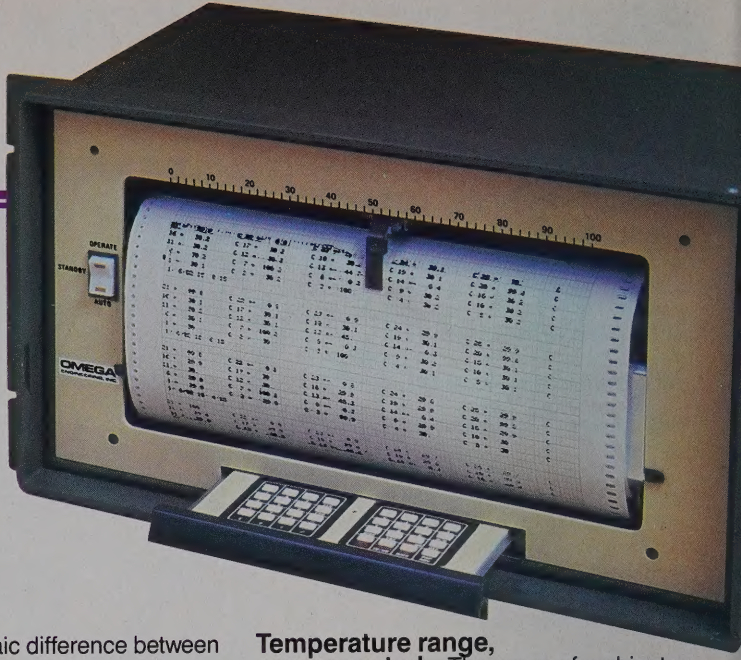
PSIS: Pounds per square inch standard. Pressure referenced to a standard atmosphere.

Pulse width modulation: An output in the form of duty cycle which varies as a function of the applied measurand.

Range: The measurand values, over which a transducer is intended to measure, specified by their upper and lower limits.

Recovery time: The length of time which it takes a transducer to return to normal after applying a proof pressure.

PRESSURE REFERENCE SECTION
GLOSSARY



Repeatability: The ability of a transducer to reproduce output readings when the same measurand value is applied to it consecutively, under the same conditions, and in the same direction. Repeatability is expressed as the maximum difference between output readings.

Resolution: The magnitude of output step changes as the measurand is continuously varied over the range. This term applies primarily to potentiometric transducers. Resolution is best specified as average and maximum resolution; it is usually expressed in percent of full scale output.

Resonant frequency: The measurand frequency at which a transducer responds with maximum amplitude.

Response time: The length of time required for the output of a transducer to rise to a specified percentage of its final value as a result of a step change of measurand.

Room conditions: Ambient environmental conditions under which transducers must commonly operate.

Self heating: Internal heating of a transducer as a result of power dissipation.

Sensing element: That part of the transducer which reacts directly in response to the measurand.

Sensitivity: The ratio of change in transducer output to a change in the value of the measurand.

Sensitivity shift: A change in slope of the calibration curve due to a change in sensitivity.

Shearing strain: A measure of angular distortion also directly measurable, but not as easily as axial strain.

Shear modulus: The ratio of the shear stress and the angular shear distortion.

Shear stress: Where normal stress is perpendicular to the designated plane, shear stress is parallel to the plane.

Signal conditioning: To process the form or mode of a signal so as to make it intelligible to, or compatible with, a given device, including such manipulation as pulse shaping, pulse clipping, compensating, digitizing, and linearizing.

Smallest bending radius: The smallest radius that a strain gage can withstand in one direction, without special treatment, without suffering visible damage.

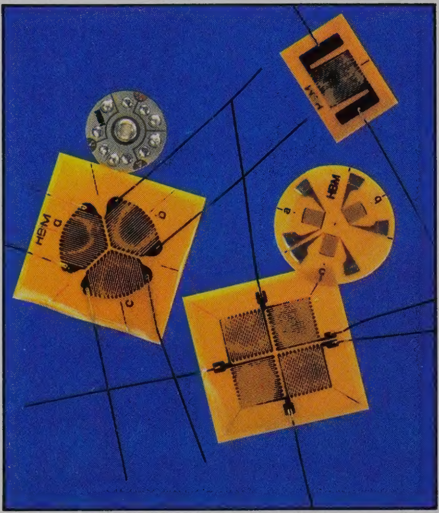
Span: The algebraic difference between the limits of the range.

Stability: The ability of a transducer to retain all its performance throughout its life span.

Static calibration: A calibration recording pressure versus output at fixed points at room temperature.

Static error band: The error band applicable at room temperature.

Strain: The ratio of the change in length to the initial unstressed reference length.



Strain gage: A measuring element for converting force, pressure, tension, etc., into an electrical signal.

Temperature error: The maximum change in output, at any measurand value within the specified range, when the transducer temperature is changed from room temperature to specified temperature extremes.

Temperature range, operable: The range of ambient temperatures, given by their extremes, within which the transducer may be operated. Exceeding compensated range may require recalibration.

Temperature range, compensated: The range of ambient temperatures within which all tolerances specified for Thermal Zero Shift and Thermal Sensitivity Shift are applicable (temperature error).

Thermal coefficient of resistance: The change in resistance of a semiconductor per unit change in temperature over a specific range of temperature.

Thermal sensitivity shift: The sensitivity shift due to changes of the ambient temperature from room temperature to the specified limits of the compensated temperature range.

Thermal zero shift: An error due to changes in ambient temperature in which the zero pressure output shifts. Thus, the entire calibration curve moves in a parallel displacement.

Transducer: A device (or medium) that converts energy from one form to another. The term is generally applied to devices that take physical phenomenon (pressure, temperature, humidity, flow, etc.) and convert it to an electrical signal.

Typical: Error is within plus or minus one standard deviation (±1) of the nominal specified value, as computed from the total population.

Vacuum: The weight of the atmosphere on earth produces a pressure equal to that produced by a column of mercury about 30″ high.

Vibration error: The maximum change in output of a transducer when a specific amplitude and range of frequencies are applied to a specific axis at room temperature.

Vibration error band: The error recorded in output of a transducer when subjected to a given set of amplitudes and frequencies.

Young's Modulus: Young's Modulus (the Modulus of Elasticity) is equivalent to the ratio of normal stress to strain.

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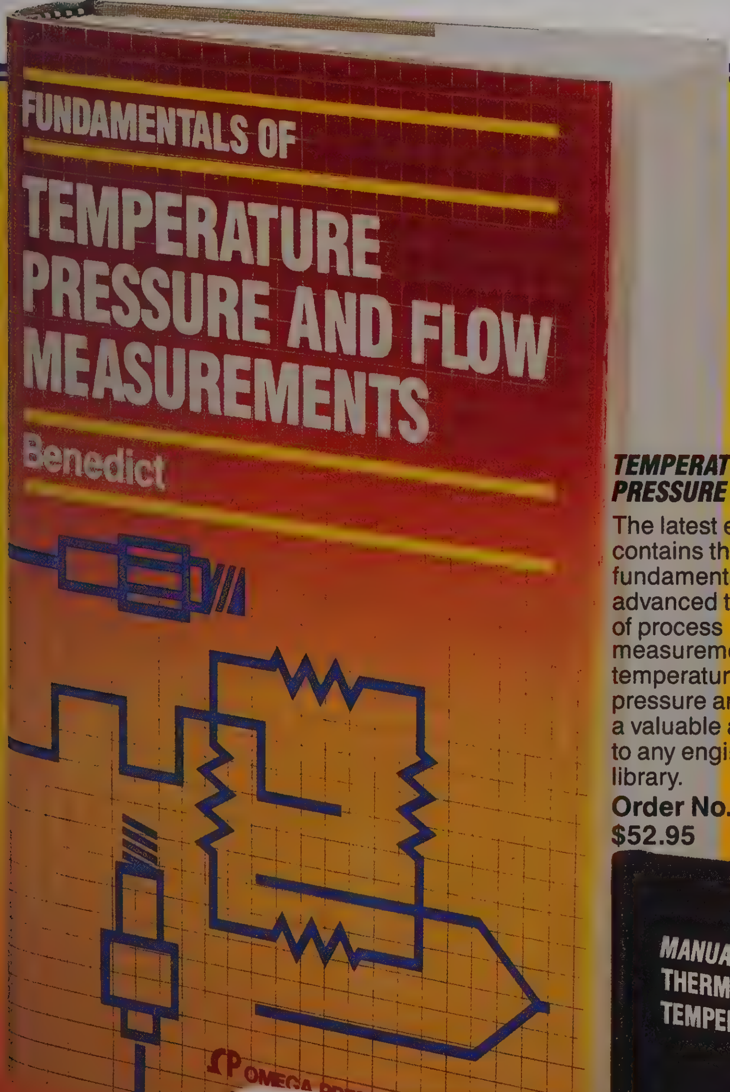
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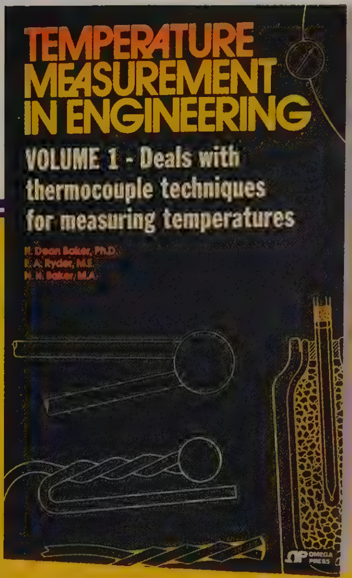
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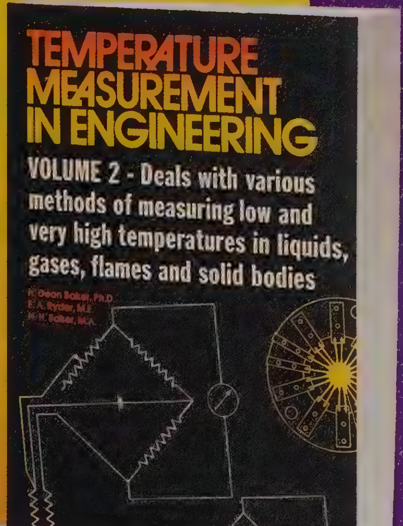
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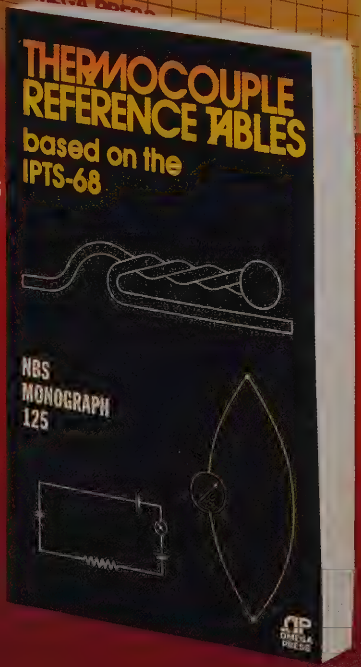
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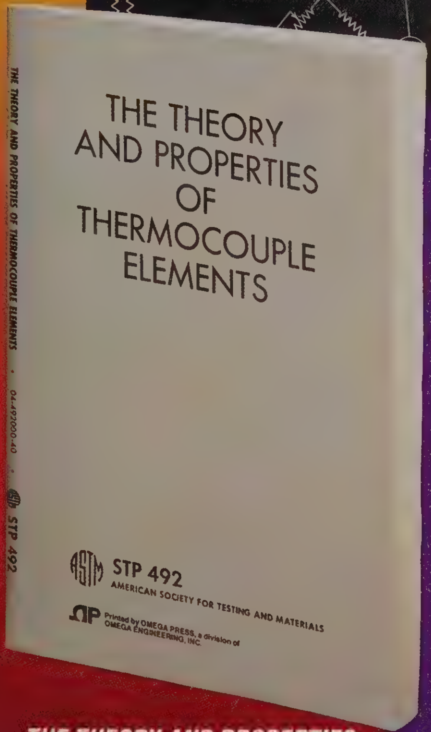
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INTRODUCTION

The OMEGA® Pressure Transducers utilize semiconductor or foil grid strain gages. The strain gage is one of the most important tools of the electrical measurement technique applied to the measurement of mechanical quantities. As their proper name indicates, they are used for the measurement of strain. As a technical term "strain" is comprised of tensile and compressive strain, distinguished by a positive or negative sign. Thus, strain gages can be used to pick up expansion as well as contraction.

The strain of a body is always caused by an external influence or an internal effect. Strain might be caused by forces, pressures, heat, or structural changes of the material. If certain conditions are fulfilled, the amount or the value of the influencing quantity can be derived from the measured strain value. In experimental stress analysis, this feature is widely used. Experimental stress analysis uses the strain values measured on the surface of a specimen or structural part to state the stress in the material and also to predict its safety and endurance. Special tranducers can be designed for the measurement of forces or other derived quantities, e.g. moments, pressures, accelerations, displacements, vibrations and others. The tranducer generally contains a pressure sensitive diaphragm with strain gages bonded to it.

PRESSURE SENSOR VS PRESSURE TRANSDUCER

OMEGA® Pressure Transducers are composed of pressure sensors (diaphragm and strain gages) coupled with compensation networks. The pressure sensor, by itself, is incomplete; it is a subcomponent for a calibrated transducer.

Within the last several years, pressure sensors in the form of integrated circuits with etched pressure-sensitive diaphragms have been introduced. These sensors are frequently called transducers, and users expect them to accurately measure pressure directly without additional network compensation, but they will not do so (see Figure 1 and Table 1). The calibration and compensation of pressure sensors are the most expensive steps in the transducer manufacturing process. This process requires special equipment, technical skills, proprietary knowledge about the chip, and a program to calibrate for the extreme parameters of the chips to be purchased.

In order to be complete, the sensor must have either intrinsic in its design or added to it the following properties:

1. **An integral pressure interface** (diaphragm) that isolates and couples the measurand to the sensing elements (strain gages).

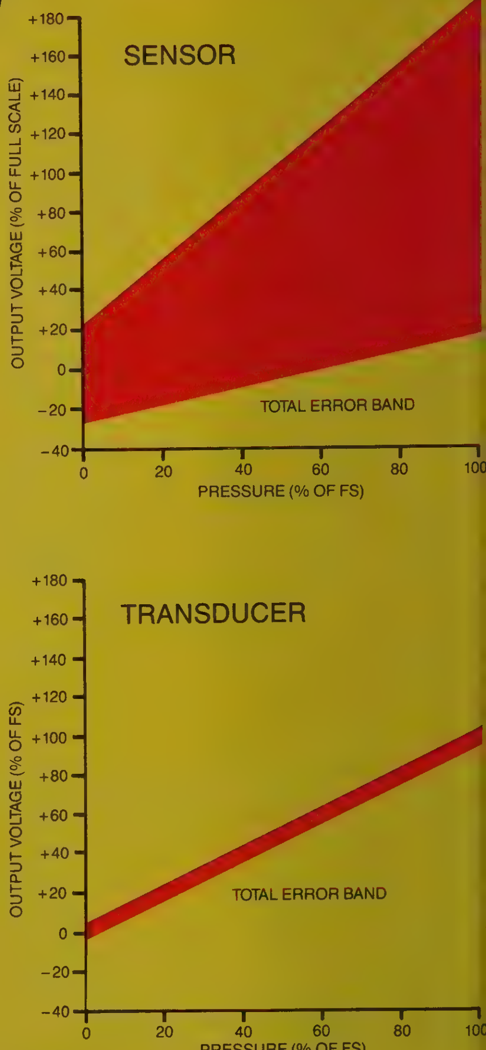


Figure 1

2. Minimal thermal coefficients of expansion and contraction of all sensor parts (or alternatively self-compensating parts) between the sensor and all mechanical interfaces;

3. Excellent linearity, hysteresis, and repeatability.

Regardless of complexity, no procedure would yield a satisfactory calibrated transducer if its sensor did not have these properties. Sensors having these properties are now ready to be compensated.

TABLE 1
COMPARING OPERATING SPECIFICATIONS

Typical Sensor	Parameter	Typical Transducer
±50%	Sensitivity	±1%
±20%	Zero balance (null)	±1%
±0.5%	Nonlinearity and hysteresis	±0.5%
±10%	Thermal pressure coefficient	±0.5%
±5%	Thermal zero coefficient	±0.5%
to be calibrated	Total error band	1.5% RSS

The objective in calibration is to:

1. Make the sensor into a transducer that is interchangeable from unit to unit without readjustment;

2. Compensate for the nonlinear characteristics of the strain gage.

The typical specifications shown in Table 1 illustrate that the sensor output for a given pressure input must be calibrated to make it useful. Figure 2, while not illustrating all of the calibration and compensation methods available to the user or the transducer manufacturer, serves to illustrate the scope of the tasks involved in transforming a sensor into a calibrated transducer.

The ideal sensor application:

There is a stable (constant) operating temperature

OR

the drift due to temperature is tolerable

AND

the pressure media will be compatible with the input side of the chamber.

AND

interchangeability is not a requirement — zero and gain adjustments are accessible.

Operating temperature is seldom stable and drift with temperature is very extensive. The sensor must be compensated over the operating temperature range both at zero and full pressure to be stable.

If temperature is not a factor, then only sensitivity and zero balances must be set (see Table 2). The values for trim resistors will vary from unit to unit.

If temperature is a factor, adjust for A, B, C, and D according to Table 2. Each adjustment has some effect upon the others, and the cycle may have to be repeated for close tolerances of ±2%.

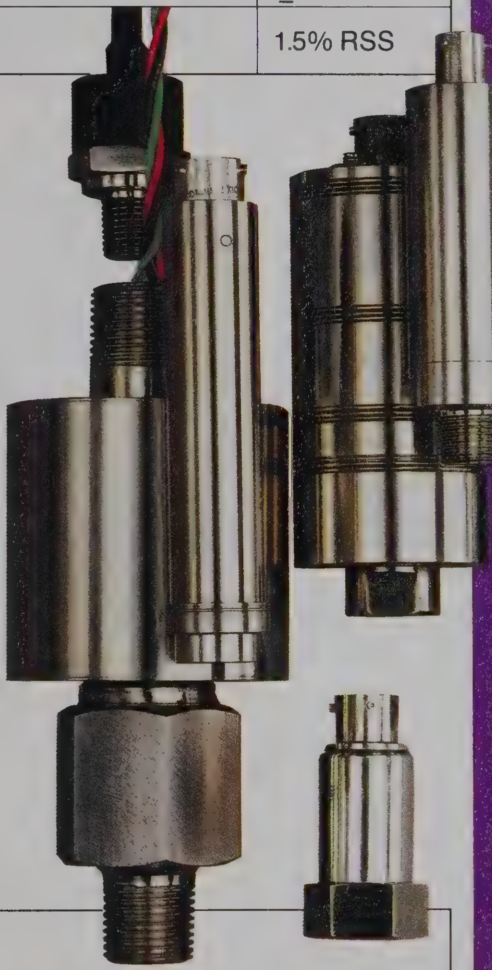


TABLE 2
COMPENSATION PROCEDURES

Compensation	Added Components	Equipment Needed	Required Knowledge	Interaction
A Sensitivity	Potentiometer or Fixed Resistor	Calibrated Pressure Source and Readout	Bridge Resistance	**C** Thermal Effect on Sensitivity
B Zero Balance	Potentiometer (2) or Fixed Resistors (2)	Power Supply and Readout	Bridge Resistance	**D** Thermal Effect on Zero
C Thermal Effect on Sensitivity	Resistor and Thermistor	Calibrated Pressure Source Temperature Chamber and Readout	Bridge Temperature Coefficient of Resistance; Bridge Temp. Coefficient of Sensitivity	**A** Sensitivity
D Thermal Effect on Zero	Fixed Resistor	Temperature Chamber, and Readout	Gage Temperature Coefficent of Resistance; Bridge Temp. Coefficient of Resistance	**A** Sensitivity **B** Zero Balance **C** Thermal Effect on Sensitivity

SENSOR + COMPENSATION PROCEDURES = TRANSDUCER

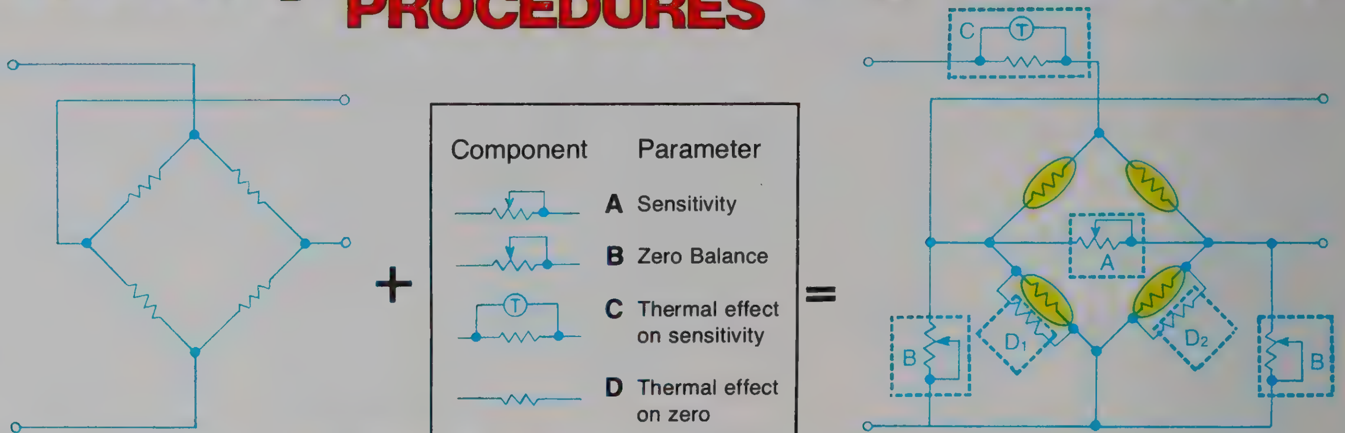
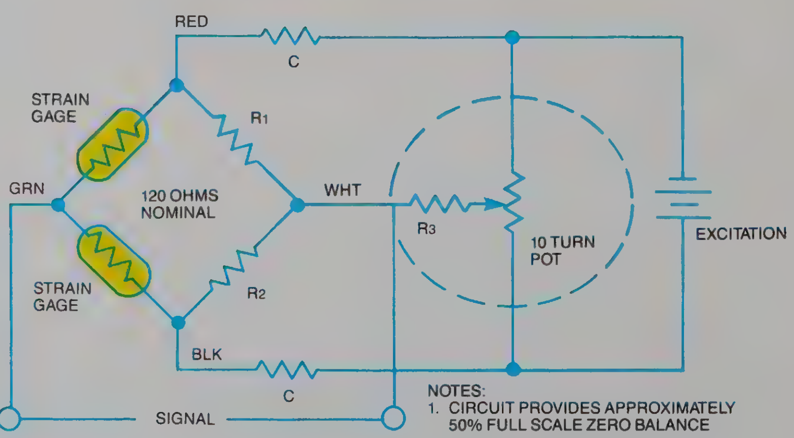

+
Component
Parameter
A Sensitivity
B Zero Balance
C Thermal effect on sensitivity
D Thermal effect on zero
=
C
T
A
B
D1
D2
B

Figure 2

D1 use if zero T.C. $\frac{\Delta EO}{\Delta T}$ is positive

D2 use if zero T.C. $\frac{\Delta EO}{\Delta T}$ is negative


RED
C
STRAIN GAGE
R1
GRN
120 OHMS NOMINAL
WHT
R3
10 TURN POT
EXCITATION
STRAIN GAGE
R2
BLK
C
SIGNAL

NOTES:
1. CIRCUIT PROVIDES APPROXIMATELY 50% FULL SCALE ZERO BALANCE
2. "C" ARE CALIBRATION ADJUSTMENT RESISTORS INSIDE TRANSDUCER

Figure 3

External Zero Balance Circuit

OMEGA transducers are fully compensated for zero balance, span and temperature. However, as with all transducers, the long-term effects of component aging require that the user provide some type of external zero balance to recalibrate the system (see Figure 3), or the zero offset can be compensated with instrumentation.

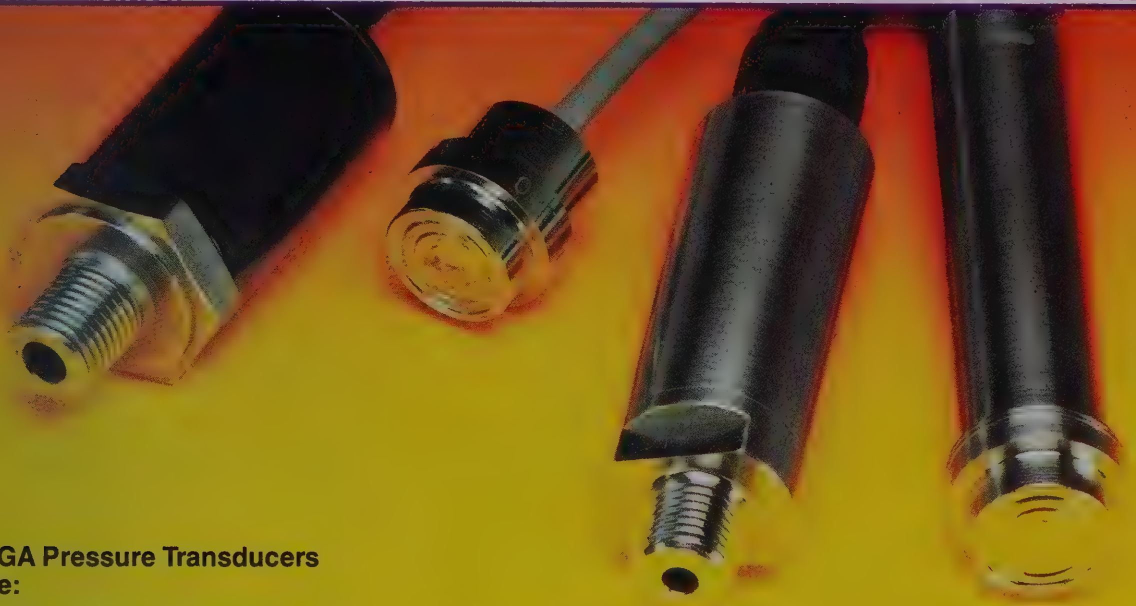
CONCLUSION

The ideal pressure transducer should be:

- **interchangeable**
- **accurate over a wide temperature range**
- **operable at temperature extremes**
- **durable within the external environment**
- **durable within the pressure environment**
- **compatible with various measurand (gases, liquids, slurries, etc.)**
- **isolated from the measurand**

Calibrating and compensating a sensor to make a calibrated transducer is not easy. It requires skill, equipment, and intimate knowledge of sensor characteristics. All OMEGA pressure transducers are fully compensated.

PRESSURE TRANSDUCERS



OMEGA Pressure Transducers utilize:

1. **Semiconductor strain gages** bonded to a silicon diaphragm (piezoresistive);
2. **Semiconductor strain gages** bonded to a stainless steel diaphragm;
3. **Foil grid strain gages** bonded to a stainless steel diaphragm.

PIEZORESISTIVE (SILICON) DIAPHRAGMS

Operating Principle

Piezoresistance of a semiconductor can be described as the change in resistance that is caused by an applied strain of the diaphragm. Thus, solid state resistors can be used as pressure sensors, much like wire strain gages, but with several important differences and advantages.

The high sensitivity, or gage factor, is perhaps 100 times that of wire strain gages. Piezoresistors are diffused into a homogeneous single crystalline silicon medium. The diffused resistors are thus integrated into the silicon force sensing member. Typically, other types of strain gages are bonded to force sensing members of dissimilar material, resulting in thermo-elastic strain and complex fabrication processes. Most strain gages are inherently unstable due to degradation of the bond, as well has temperature sensitivity and hysteresis caused by the thermo-elastic strain.

Silicon is an ideal material for receiving the applied force. Silicon is a perfect crystal and does not become permanently stretched. After being strained, it returns to the original shape. Silicon wafers are better than metal for pressure sensing diaphragms, as silicon has extremely good elasticity within its operating range. Silicon diaphragms normally fail only by rupturing.

Technical Description

The sensing element consists of four nearly identical piezoresistors buried in the surface of a thin circular silicon diaphragm. Gold pads attached to the silicon diaphragm surface provide connection to the piezoresistors, and serve as pads for probe type resistance measurements, or for bonding of wire leads. The thin diaphragm is formed by chemically etching a circular shaped cavity into the surface opposite the piezoresistors. The unetched portion of the silicon slice provides a rigid boundary constraint for the diaphragm and a surface for mounting to some other member. Figure 4 is a cross-sectional view of the sensing element with wire leads bonded to the metal contacts.

A pressure causes the thin diaphragm to bend, inducing a stress or strain in the diaphragm and also in the buried resistor. The resistor values will change depending on the amount of strain they undergo, which depends on the amount of pressure applied to the diaphragm. Hence, a change in pressure (mechanical input) is converted to a change in resistance (electrical output). The sensing element converts (transduces) energy from one form to another.

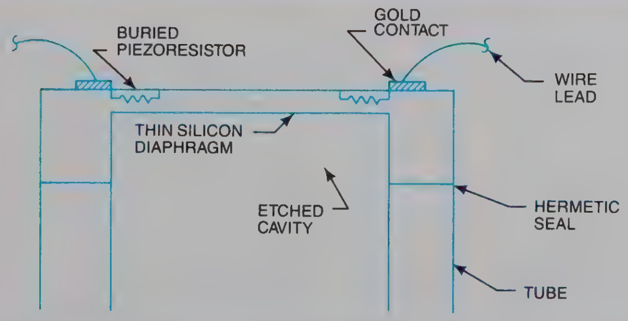


Figure 4

PRESSURE TRANSDUCERS CONTINUED

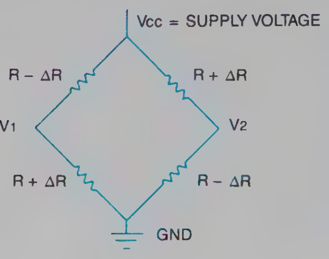


Figure 5

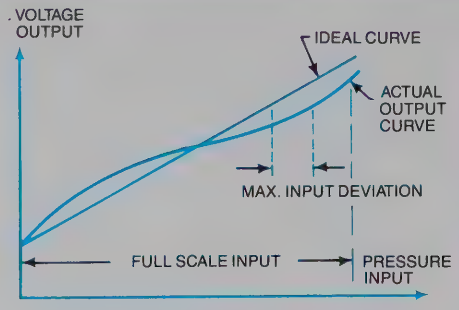


Figure 6

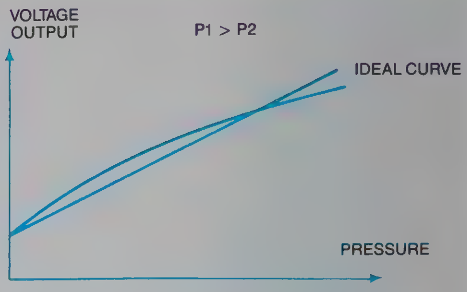


Figure 8

The resistors can be connected in either a half-bridge or a full Wheatstone bridge arrangement. For a pressure applied to the diaphragm using a full bridge arrangement, the resistors can theoretically be approximated as shown in Figure 5 (non-amplified units).

$R + \Delta R$ and $R - \Delta R$ represent the actual resistor values at the applied pressure. R represents the resistor value for the undeflected diaphragm, pressure equals zero where all four resistors are nearly equal in value. ΔR represents the change in resistance due to an applied pressure. All four resistors will change by approximately the same value. Note that two resistors increase and two decrease depending on their orientation with respect to the crystalline direction of the silicon material.

The signal voltage generated by the full bridge arrangement is proportional to the amount of supply voltage (V_{cc}) and the amount of pressure applied which generates the resistance change ΔR.

The nonlinearity of the voltage output curve is of considerable importance, since it can represent a significant source of error in the transducer measuring device. A convenient way of defining nonlinearity is to express it as a percentage of the full scale input (pressure). Thus:

$$\%\text{ Nonlinearity} = \frac{\text{Maximum Input Deviation}}{\text{Full-Scale Input}} \times 100$$

Figure 6 illustrates the maximum input deviation.

Diaphragms of different thicknesses produce different transducer output curve shapes, when the diaphragm is deflected by a pressure greater at P1 than P2 (see Figure 7).

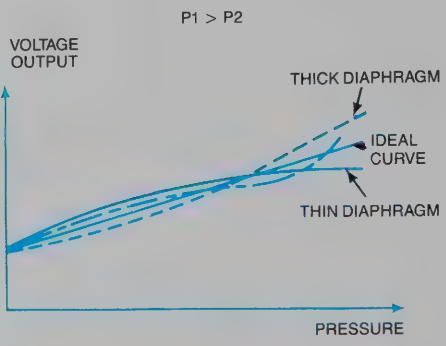


Figure 7

Diaphragms deflected in the opposite direction (P1 < P2) exhibit nonlinearity curves of one shape only, regardless of diaphragm thickness as shown in Figure 8.

When the diaphragm is deflected in both directions, the nonlinearity curve shape will be a combination of Figures 8 and 9.

Zero pressure does not produce zero output. There is some voltage through the unit, even with zero scale reading. This is called the null offset or null voltage, and represents the beginning point of the transducer response graph.

Transducer Types

Pressure may be applied to both sides of the sensing chip. P1 is the termination side and only clean dry gases such as air are recommended as measurands on this side. Fewer restrictions apply to the P2 side, except that media incompatible with polyester, silicon, or silicone based adhesive should not be used.

In absolute devices, P2 is sealed with a vacuum representing a fixed reference. The difference in pressure between the vacuum reference and the measurand applied at P1 causes the deflection of the diaphragm, producing the output voltage change.

Differential and gage devices measure one pressure with respect to another. In differential devices, measurands are applied to both ports. In gage devices, P1 is vented to atmospheric pressure, and the measurand is applied to the P2 port.

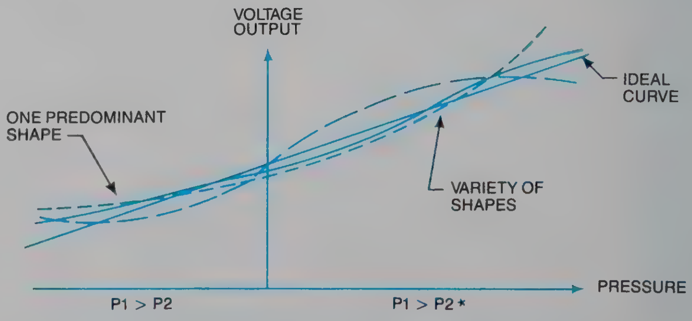


Figure 9

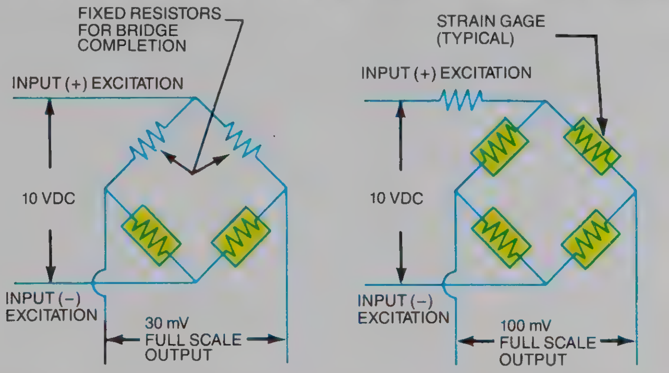
**The deflection results in the lower % of Full Scale Output tolerance for Linearity and Hysteresis.*

STAINLESS STEEL DIAPHRAGM (WITH SEMICONDUCTOR STRAIN GAGES)

Operating Principle

OMEGA also offers pressure transducers which utilize semiconductor strain gages that are epoxy bonded to a stainless steel diaphragm. Pressure applied to the diaphragm through the pressure port produces a minute deflection which introduces strain to the gages. The strain produces an electrical resistance change proportional to the pressure. Four gages (or two gages with fixed resistors) form a Wheatstone Bridge (see Figure 10).

Figure 10


FIXED RESISTORS FOR BRIDGE COMPLETION
INPUT (+) EXCITATION
10 VDC
INPUT (–) EXCITATION
30 mV FULL SCALE OUTPUT
STRAIN GAGE (TYPICAL)
INPUT (+) EXCITATION
10 VDC
INPUT (–) EXCITATION
100 mV FULL SCALE OUTPUT

TWO STRAIN GAGES IN A BRIDGE (HALF BRIDGE UNIT)

FOUR STRAIN GAGES IN A BRIDGE (FULL BRIDGE UNIT)

The differential resistance is measured by applying a constant voltage to the bridge. Diaphragm deflection results in an analog (millivolt) output which is proportional to the pressure.

Fixed resistors are used for bridge completion (in half bridge units), temperature compensation, zero balance and to achieve full scale output.

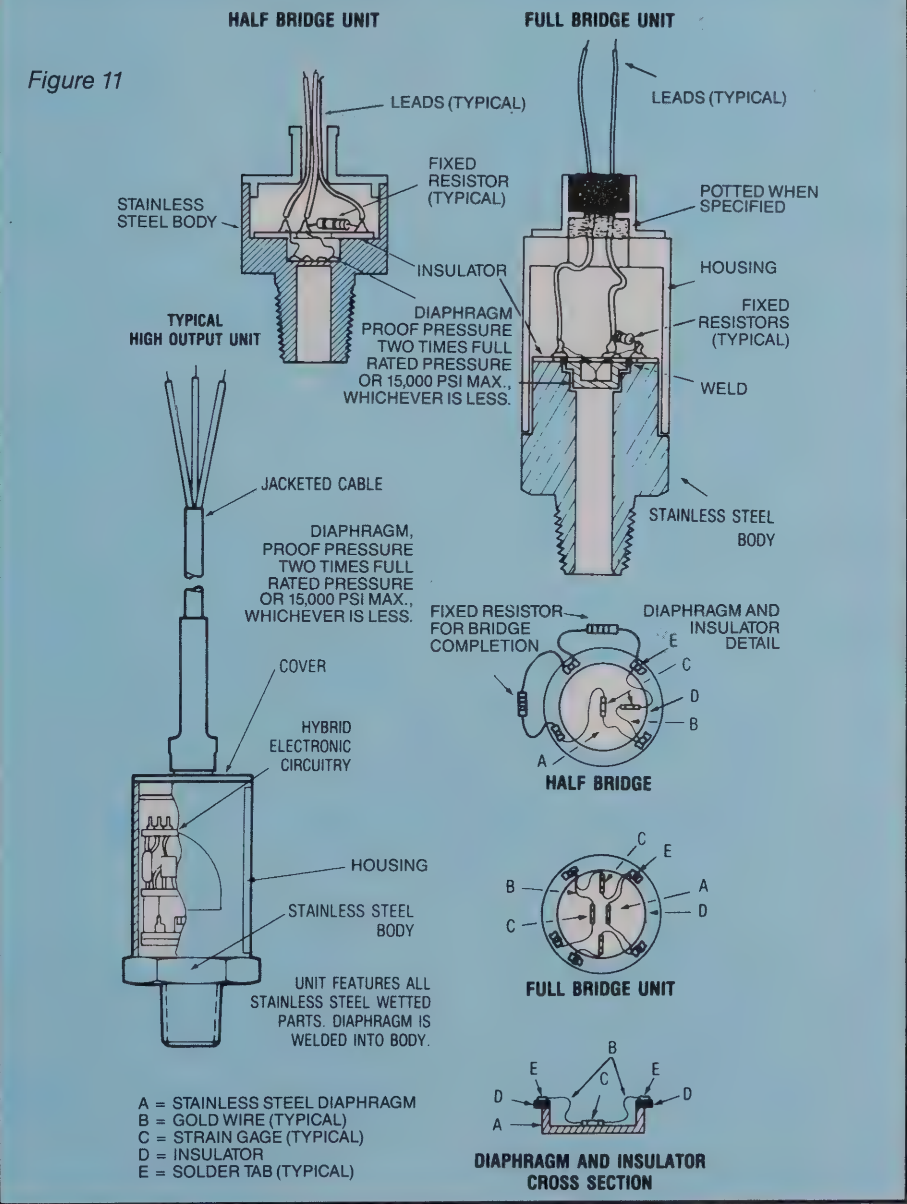
Various output voltages can be provided through amplifier or other signal conditioning circuits internal or external to the transducer. Also other supply voltages are accommodated by using appropriate internal circuitry.

Semiconductor Gage Characteristics

Semiconductor gage characteristics provide overall accuracy and performance. OMEGA manufactures semiconductor strain gages to its own specifications of resistance, strain levels and thermal characteristics. They are manufactured from pure single crystal silicon wafers which are processed through steps of oxidation, wafer alignment, photo etching and diffusion. Gold wire welded to the gage ends is used as a conductor to the solder tabs to provide maximum conductivity and thus constant resistance values.

The initial resistance values as manufactured are measured and closely controlled. Then the resistance at 70°F, 30°F and 130°F is measured. The gages are assembled in sets which have thermal

Figure 11


HALF BRIDGE UNIT
FULL BRIDGE UNIT
LEADS (TYPICAL)
LEADS (TYPICAL)
STAINLESS STEEL BODY
FIXED RESISTOR (TYPICAL)
POTTED WHEN SPECIFIED
INSULATOR
HOUSING
TYPICAL HIGH OUTPUT UNIT
DIAPHRAGM PROOF PRESSURE TWO TIMES FULL RATED PRESSURE OR 15,000 PSI MAX., WHICHEVER IS LESS.
FIXED RESISTORS (TYPICAL)
WELD
JACKETED CABLE
STAINLESS STEEL BODY
DIAPHRAGM, PROOF PRESSURE TWO TIMES FULL RATED PRESSURE OR 15,000 PSI MAX., WHICHEVER IS LESS.
FIXED RESISTOR FOR BRIDGE COMPLETION
DIAPHRAGM AND INSULATOR DETAIL
E
C
D
B
A
COVER
HYBRID ELECTRONIC CIRCUITRY
HALF BRIDGE
HOUSING
C
E
B
A
C
D
STAINLESS STEEL BODY
FULL BRIDGE UNIT
UNIT FEATURES ALL STAINLESS STEEL WETTED PARTS. DIAPHRAGM IS WELDED INTO BODY.
B
E
E
C
D
D
A
DIAPHRAGM AND INSULATOR CROSS SECTION

A = STAINLESS STEEL DIAPHRAGM
B = GOLD WIRE (TYPICAL)
C = STRAIN GAGE (TYPICAL)
D = INSULATOR
E = SOLDER TAB (TYPICAL)

characteristics within close tolerances. This controlled procedure is important in order to provide the strain gage characteristics necessary to consistently produce transducers that meet catalog specifications.

Bonding

The strain gages are epoxy bonded to a precision metal diaphragm, the thickness of which determines the pressure range of the transducer. The proprietary bonding method, coupled with the diaphragm design and metal finish, results in excellent long term stability.

Typical Diaphragm and Bridge Designs

Typical diaphragm and bridge designs (see Figure 11) give ±0.5% accuracy and long life (including linearity, hysteresis and repeatability).

The flat stainless steel diaphragm (designed for low stress levels) has minute movement. This results in exceptionally long life and excellent linearity. The diaphragm is either part of a single piece construction or part of an assembly which is electron-beam welded to the body. Thus the strain gages are isolated from the media and the diaphragm is protected from external strains. No other devices are needed to protect the strain gages and electronics from the media.

The diaphragm design, coupled with high output and infinite resolution of the strain gages, permits uniform accuracy and infinite pressure resolution regardless of the pressure range. The design provides optimum output vs. performance and life.

Ambient Temperature Compensation

The diaphragm and body materials have thermally matched temperature coefficients. This minimizes thermal strains due to ambient temperature changes.

The thermally matched strain gages and materials of construction plus final temperature compensation with fixed resistors result in excellent ambient temperature resistance in industrial environments.

Vibration and Shock Resistance

The rigid sensing diaphragm with bonded semiconductor strain gages and low mass, provide a no moving parts transducer with excellent resistance to shock and vibration. This makes OMEGA units particularly suited for industrial applications such as engines, compressors and over-the-road equipment which may be subject to vibration or shock.

S S DIAPHRAGM

(WITH FOIL STRAIN GAGE)

In addition to relative low cost and good accuracy, the pressure transducers (with foil strain gages on a stainless steel diaphragm) have good temperature stability and can be bonded to corrosion resistant materials. They do, however, have a low output (about 3 mV/V) which makes more amplification necessary. OMEGA offers both amplified and non-amplified transducers.

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PRESSURE TRANSDUCER APPLICATION CONSIDERATIONS

PRESSURE REFERENCE TYPES

OMEGA® pressure transducers measure absolute, differential, or gage pressure. Absolute pressure is measured with respect to a perfect vacuum, an example of which is the measurement of barometric pressure. Differential pressure is the difference between two pressures. For instance, the measurement of pressure drop across an orifice or venturi, used to compute flow rate. Gage pressure is a form of differential pressure measurement in which atmospheric pressure is used as the reference. Measurement of auto tire pressure, where a pressure above atmospheric is needed to maintain tire performance characteristics, is an example.

Figure 12 compares absolute and gage pressures at sea level. Note that the zero references are different.

TRANSDUCER EFFECTS

Pressure tranducer output is given by $V_O = V1 + S(P)$ for a regulated transducer, and $V_O = Vs\,[k1 + k2(P)]$ for a ratiometric transducer. A ratiometric transducer is one in which the output is related to the supply voltage by a ratio. For a particular supply voltage (Vs), $V1 + Vs\,(k1)$ and $S = Vs\,(k2)$ making the two equivalent. Pressure versus output relation is illustrated in Figure 13.

Null (V1) has an initial tolerance and a temperature coefficient, as does the sensitivity (S). The null temperature error will cause the whole curve to shift along the voltage axis (see Figure 14).

The sensitivity temperature error will cause a change in slope (see Figure 15). Other important effects include linearity, repeatability, and hysteresis. Linearity refers to how closely the transducer output adheres to a straight line over the desired pressure range. One method of computing linearity error is the method of least squares, which mathematically provides a "best fit" line to the data (see Figure 16).

Repeatability refers to the ability of the transducer to reproduce the same output with the same measurand applied in the same direction consecutively, as in Figure 17.

Hysteresis refers to the ability of a transducer to reproduce the same output with the same measurand applied consecutively, first with increasing pressure, then with decreasing pressure (see Figure 18).

Temperature Hysteresis refers to the ability of a transducer to reproduce the same output with the same measurand applied, at a given temperature, before and after a temperature cycle.

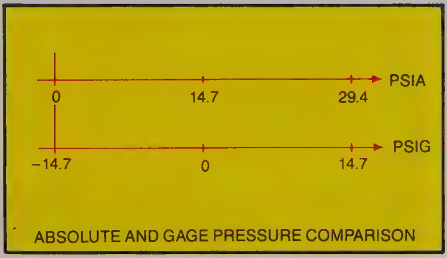


Figure 12

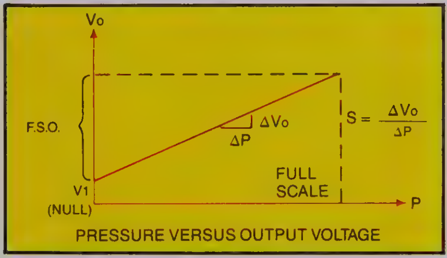


Figure 13

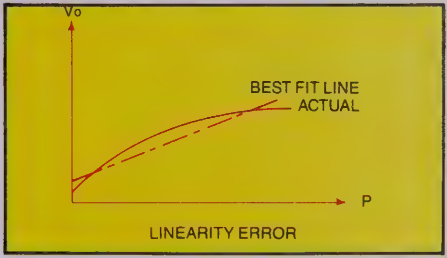


Figure 16

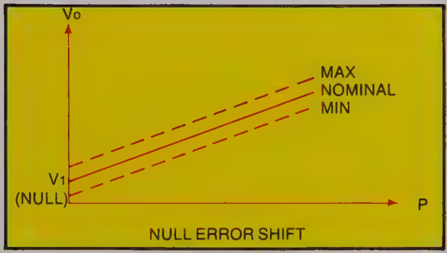


Figure 14

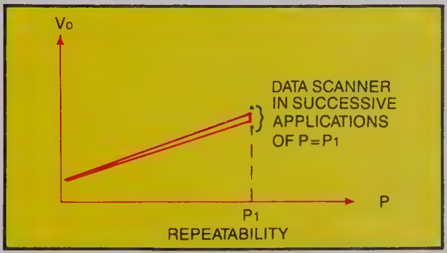


Figure 17

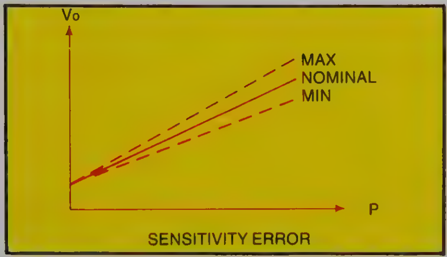


Figure 15

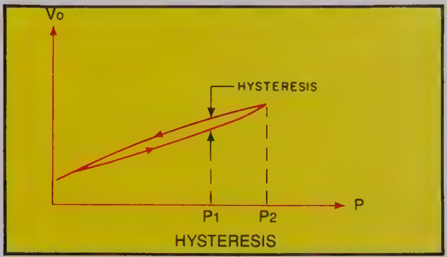


Figure 18

PRESSURE TRANSDUCERS APPLICATION CONSIDERATIONS CONTINUED

TOTAL ERROR

When choosing a transducer, the total error contribution is important. A realistic approach for computation of the total error due to several independent sources, is the root-sum-square (R.S.S.) method.

To assess the total error of a transducer over a 40°C range, for example, the following calculations can be made (values for example only):

Temperature Error =

$$\frac{40^\circ C \times 1\% = 0.5\%}{80^\circ C}$$

Linearity = 0.75%

Repeatability and Hysteresis = 0.15%

R.S.S. Error =

$$\sqrt{(0.5)^2 + (0.75)^2 + (0.15)^2} = 0.9\%$$

An alternate approach yielding the worst-case error is to compute the algebraic sum (using the same specifications).

Worst Case Error =

$$\pm 0.5 \pm 0.75 \pm 0.15 = \pm 1.4\%.$$

TRANSDUCER SELECTION

In determining which pressure transducer should be used in a given application, the first consideration is whether a low level (100 mV to 250 mV) or high level (5 V) output change with pressure is required. The next consideration is the allowed temperature error. The built-in, individually adjusted compensation of the OMEGA pressure transducers means that temperature errors are negligible in many applications.

Various requirements for measurand/material compatibility must also be considered:

1. Type and concentration of chemical the transducer is exposed to. Material resistance to a chemical is usually quite sensitive to the concentration of the chemical, and if it is diluted, the dilutant.

2. Temperature—resistance varies as temperature varies. A material may be quite resistant to a given chemical at −40°C, but may deteriorate beyond use at +100°C. As a general rule, materials are less resistant at elevated temperatures.

3. Exposure Time—the length of time a material is to be exposed to the chemical must be known. Continuous versus intermittent exposure can have a noticeable effect on performance.

4. Type of Exposure—immersion, splash, spray or fumes. Material/product performance varies depending upon the type of exposure.

5. Criteria for Failure—material may increase in volume, distort, or otherwise change in appearance, but still perform functionally. It is important to be specific on what the user considers to be a failure.

6. General Information—application environment, protection of the device, other foreign substances in the area, etc.

TYPICAL APPLICATIONS

DIFFERENTIAL PRESSURE MEASUREMENTS

It is often desirable to make differential pressure measurements by using two transducers. This is particularly true when the transducers must be flush mounted in sanitary applications or to maximize frequency response.

The circuit shown in Figure 19 may be used with OMEGA PX-102 pressure transducers.

Set-up Procedure

1. With no pressure applied, set zero balance using potentiometer R_1.

2. Apply full scale pressure to both transducers simultaneously. Adjust potentiometer R_2 for zero output.

3. System is now ready for use. Output will be approximately 50 mV for full scale differential and will operate bi-directionally.

HIGH TEMPERATURE PRESSURE MEDIA

Frequently it is necessary to measure the pressure of fluids which are at temperatures either above or below the operating range of available transducers. The expense of a special transducer can often be avoided if the pressure transducer is isolated from the pressure source by a short length of pipe or tubing.

The curves (see Figure 20) suggest tubing lengths of various sizes and materials to limit the temperature at the transducer to a range of 0°F to 200°F for fluid temperatures between −400°F and +1700°F. These curves are based on the following assumptions:

1. The pressure vessel is insulated to limit radiant heat transfer to the transducer. Thus, the major source of thermal input is via the connecting tubing.

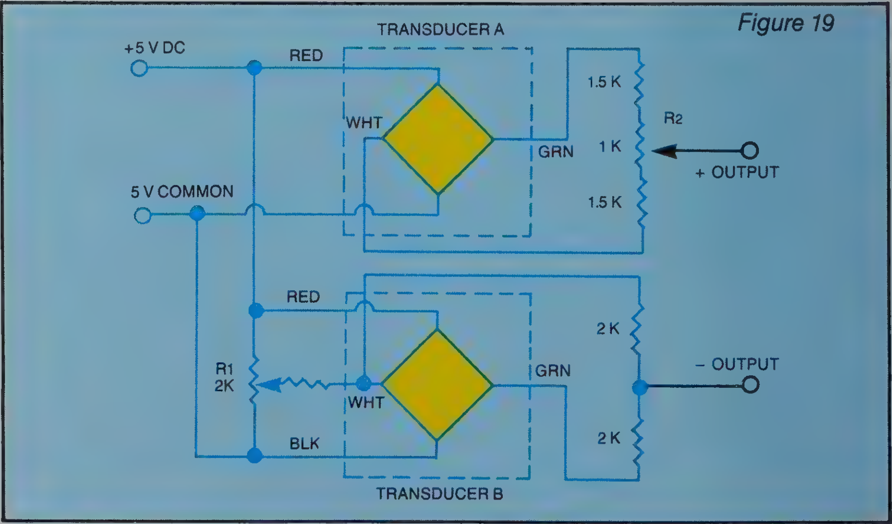


Figure 19

2. The pressure medium has a coefficient of thermal conductivity less than 0.4 BTU/hr/ft/°F. This figure encompasses a wide range of liquids and gases.

3. The ambient temperature around the transducer is 100°F.

4. The heat transfer rate (convection) from the tubing to still air is 1.44/BTU/ft/hr/°F.

Deviation from these conditions will require some slight adjustments in the length of tubing selected. Or, if there is any doubt, a thermocouple on the transducer will readily verify proper operating conditions.

Note that a 6″ length of 1/4″ stainless steel tubing will effectively protect a transducer from a 1000°F pressure source. Thus, pressure transducers capable of operating at 200°F can measure the pressure of fluids having much higher temperatures.

APPLICATION FLEXIBILITY

OMEGA PX-102, PX-510, PX-440 pressure transducers may all be used interchangeably in a wide variety of adaptors. These adaptors are simple two-piece fittings which house the transducer. They not only interface with the working system, but also shield the transducer from the mechanical environment.

Nine standard types are available to adapt to almost any application.

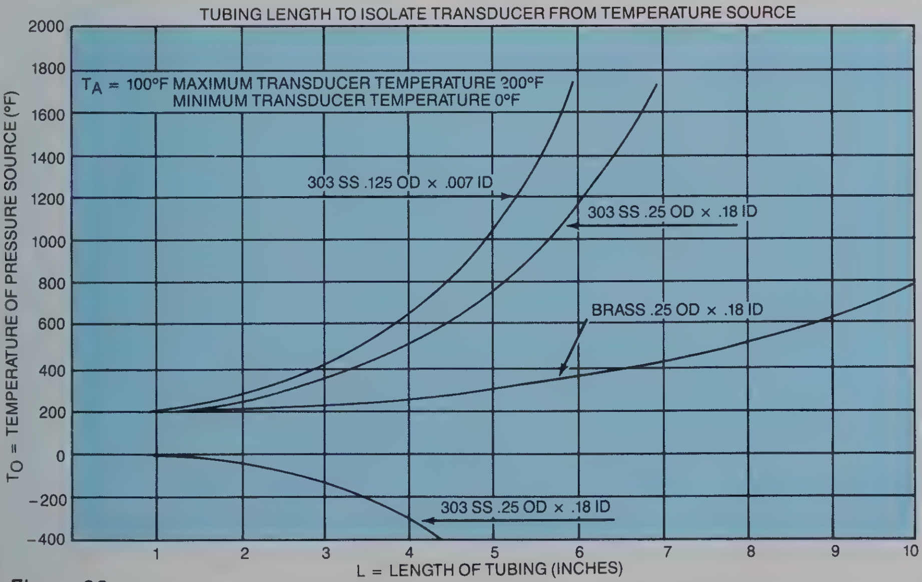


Figure 20

Several thread types, case materials and pressure ratings allow the basic pressure transducer to be used in a variety of areas from marine to medical and from low pressures to over 20,000 psi. Several other custom designs exist to accommodate flush mount and integral pressure port requirements.

AUTOMOTIVE DIAGNOSTICS

Application: Measurement of fuel injection, transmission hydraulics, and coolant pressures on production line European luxury automobile.

Problem: Automobiles manufactured in Europe are designed and built for European drivers, driving conditions, and pollution standards. Changes in performance characteristics and operating standards to accommodate American drivers and U.S. EPA regulations must be made—product monitoring to this end is necessary.

Among variable pressures requiring measurement in this program are cooling system, hydraulic transmission, and fuel injection. It is necessary to log these parameters, along with speed engine rpm, etc., as the car is driven under a variety of operating conditions.

Automotive engines are hot, vibrate to significant "g" levels, and have a great deal of electrical noise.

Solution: OMEGA PX-102 transducers with OMEGA AD-1SS adaptors are mounted directly on the engine or its auxiliary fluid systems. In some cases, small "standoffs" are used where engine temperatures exceed 210°F. A customer designed signal conditioner is powered by the car's battery and receives the 0-100 mV transducer output from under the hood, amplifies it, and transmits the resulting signal to a data logger (see Figure 21).

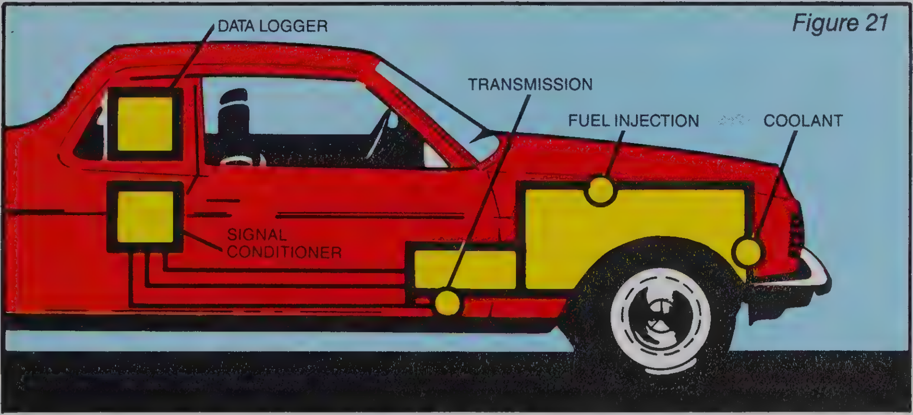


Figure 21

Incoming cars are routinely tested on a sampling basis in this fashion to insure that factory adjustments to U.S. conditions are uniform and meet performance standards.

Environments: Operating temperatures 150° to 250°F; vibration ±3 g's 20-50 Hz; humidity 90%.

Pressure Characteristics: Fuel injection, coolant, and hydraulic transmission pressures are all in the 0-100 psi range, subject to abrupt step changes with superimposed ripple.

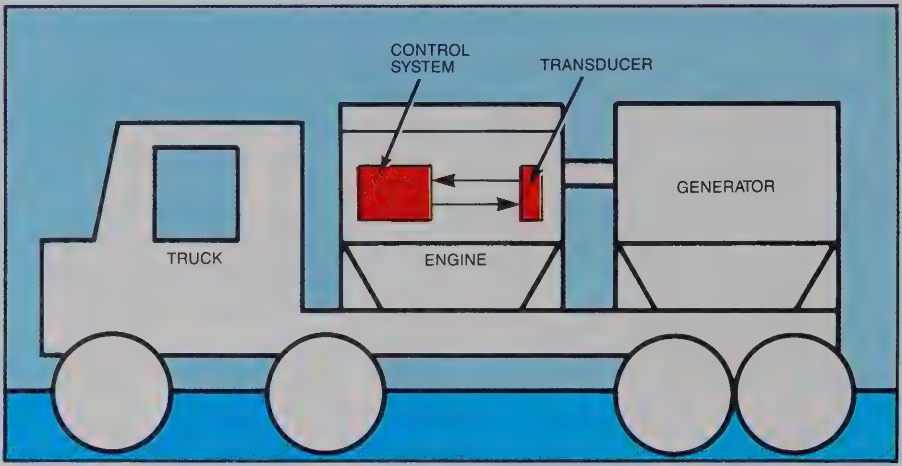

CONTROL SYSTEM
TRANSDUCER
GENERATOR
TRUCK
ENGINE

Figure 22

DIESEL ENGINE SAFETY SYSTEMS

Application: Measurement of lube oil pressure in diesel engine generator sets.

Problem: Diesel engine generator sets are used either for emergency standby power generation (typically in hospitals) or full time power generation in remote locations. Absolute reliability is essential; should lube oil pressure fail for any reason, the engine would destroy itself if not stopped within 30-45 seconds.

Solution: A modified OMEGA PX-102 transducer is mounted directly on the engine and senses lube oil pressure, generally at the 70-80 psi level (see Figure 22).

The 0-100 mV signal transmitted to customer supplied electronics activates a control circuit that will stop the engine if lube oil pressure falls below a preset limit.

Environments: Operation in diesel engine environments calls for several modifications of our standard transducer:

(1) Special high temperature cable and adhesives are used to insure operation at temperatures approaching 300°F.

(2) An integral pressure port is welded to the transducer to aid in ease of installation and to insure continued operation in 5-500 Hz environments.

(3) Special testing is required to insure accuracy and interchangeability of 1% over the working temperature range of 150° to 250°F.

Pressure Characteristics: Pressures are initially quite high during cold weather startups and transducer can be over-ranged. Pressure is generally steady state and the sensor is not subjected to spikes or periodic fluctuations.

GEOPHYSICAL PROSPECTING

Application: Level control of seismic streamers.

Problem: Seismic streamers are long waterproof arrays of sonic detection apparatus which receive and transmit echoes from the ocean floor to a shipboard analyzer.

Proper analysis of these echoes requires that the streamer be parallel to the ocean surface — each end must be at the same depth. A streamer is quite long and towed at some distance from the ship. Should it lose forward speed it may sink to depths considerably lower than its design usage before it can be reeled aboard.

Solution: An OMEGA transducer is mounted at each end of the array and measures sea water pressure (level). The ends of the streamer are at identical depths when both sensor

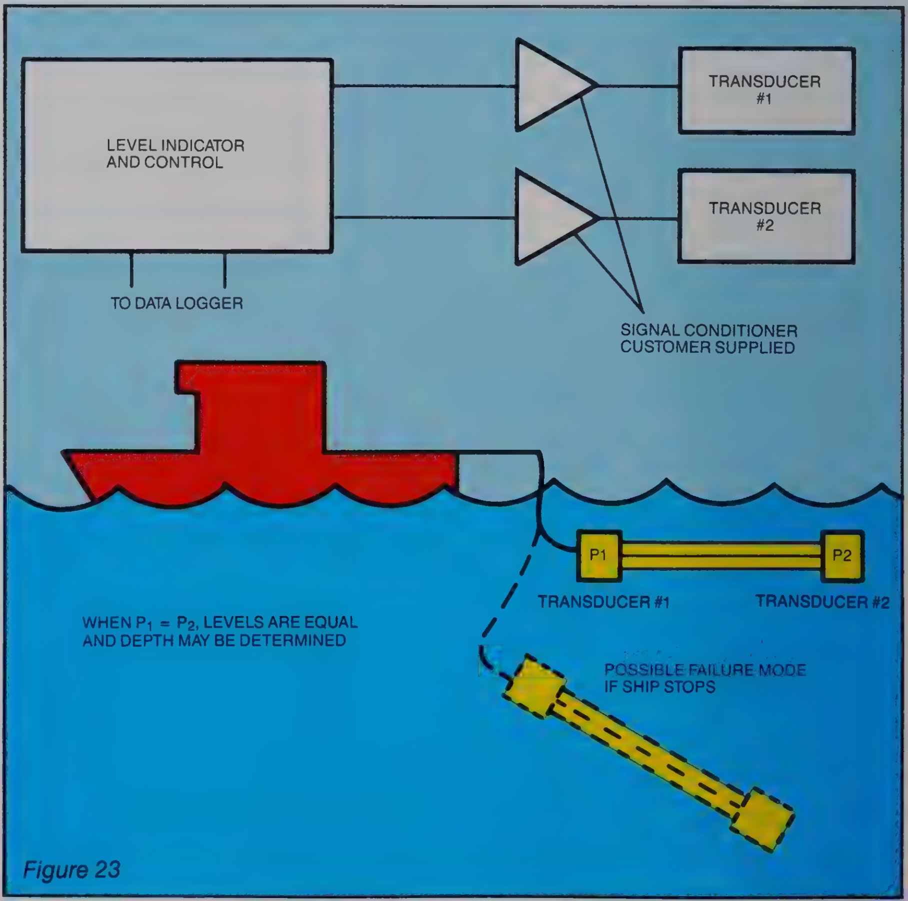

LEVEL INDICATOR AND CONTROL
TRANSDUCER #1
TRANSDUCER #2
TO DATA LOGGER
SIGNAL CONDITIONER CUSTOMER SUPPLIED
P1
P2
TRANSDUCER #1
TRANSDUCER #2
WHEN $P_1 = P_2$, LEVELS ARE EQUAL AND DEPTH MAY BE DETERMINED
POSSIBLE FAILURE MODE IF SHIP STOPS

Figure 23

outputs are observed and noted to be equal. This is possible due to the high accuracy and stability of the OMEGA transducers. (In case you were wondering, streamer design does not permit the use of a differential pressure device and requires the use of two independent transducers instead.) See Figure 23.

In addition to their operating peformance, OMEGA pressure transducers are desirable in view of their five times over-range capability. If a streamer sinks, the transducer can see five times design depth without damage or loss of calibration.

Customer supplied electronics transmit level information back to the ship for monitoring, logging, and control.

Environments: The streamer sees all marine environments from arctic to tropical. The transducer is exposed to sea air and water as well as shipboard shock. Severe overpressures may be experienced.

Pressure Characteristics: Other than overpressures, pressures are mildly modulating to steady.

SEWAGE LEVEL CONTROL

Application: Regulation of sewage pumps to maintain tank level in unattended treatment stations.

Problem: Sewage is held in agitated holding tanks. Its liquid level is maintained between predetermined points by a sensor which turns a high volume pump "on" (high level) or "off" (low level).

Sewage will foul, clog or corrode conventional level sensors. It may also contain solid objects as large as cinder blocks or 2 × 4's. Because of its composition, there is always the risk that the pump may be damaged or the line clogged, and sewage may not actually move from the tank in spite of control commands. A positive indication of movement is necessary to insure system and equipment safety. A pressure measurement in the lines to and from the pump is used to detect fluid movement.

As a consequence of the pump's operation, transient high pressure pulses (or spikes) are generated at its discharge side. These can be eight or ten times the normal running pressure and, while lasting only several milliseconds, could damage an unprotected transducer.

When the pump is turned off, a check valve within the pump will close. As sewage falls back to this valve, a "water hammer" (short duration pressure pulses or shock generated by a rapid change in flow rate) effect occurs.

In short, this application has two difficult measurements—the first being one of level, and the second being one of pump discharge pressure. Both measurements involve difficult media.

Solution: The measurement of liquid level is accomplished by mounting a PX-102-15 psig pressure transducer on the discharge side of a highly reliable commercial aquarium air pump. The pressure required to bubble air through an immersed pipe is directly related to liquid level (see Figure 24). By using a large pipe, the possibility of clogging is reduced and the system is made relatively self-cleaning. This method also safeguards the transducer since it need not be immersed while sensing liquid level. A nylon adaptor with a "T" threaded into its front is used to mount the transducer.

Normal pump discharge pressure was rated at 20 psi. In view of the eight to ten times greater than normal pressure spikes, a 0-100 psig transducer was used to sense flow from the pump. Since it could be over-ranged to 200 psig without damage (10 times normal working pressure), it was determined that this gave maximum reliability coupled with maximum practical sensitivity of flow detection. The ability of the transducer to withstand vacuum "underpressures" is also important because falling heads after the pump is turned off can create partial vacuums at the transducer on the inlet side.

The discharge transducer is

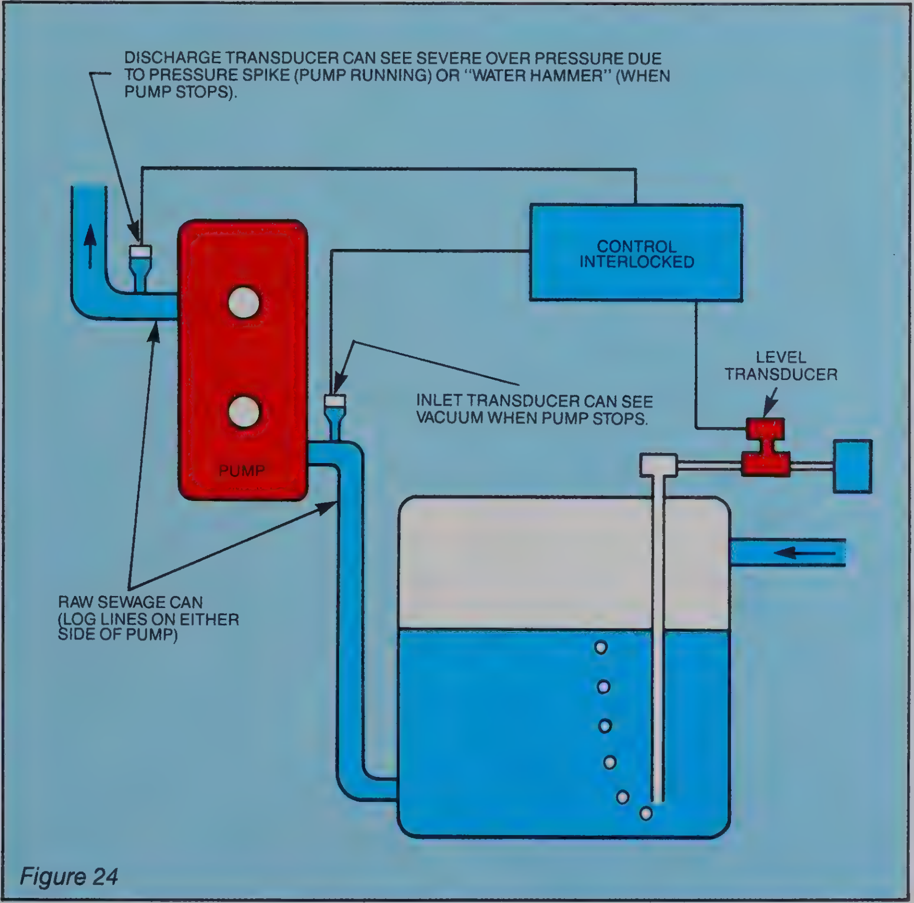

DISCHARGE TRANSDUCER CAN SEE SEVERE OVER PRESSURE DUE TO PRESSURE SPIKE (PUMP RUNNING) OR "WATER HAMMER" (WHEN PUMP STOPS).
CONTROL INTERLOCKED
PUMP
LEVEL TRANSDUCER
INLET TRANSDUCER CAN SEE VACUUM WHEN PUMP STOPS.
RAW SEWAGE CAN (LOG LINES ON EITHER SIDE OF PUMP)

Figure 24

mounted in an AD-1SS adaptor in a “drain” position. (Pressure “snubbers” cannot be used to dampen pressure spikes over prolonged periods of time due to the clogging nature of the media.)

Environments: Both level and discharge transducers are mounted in enclosures and do not see weather extremes. Atmospheres are mildly corrosive, generally humid, and, on occasion, explosive.

Pressure Characteristics: Level transducer: pressure constantly changes from 2-12 psig with random ripple resulting from surging sewage. Pump transducers: pressure ranges from partial vacuum to 20 psi with random spikes to 200 psi.

WATER LEVEL CONTROL

Application: To monitor and control water level in water towers.

Problem: Municipal and private water towers must have a control system to govern the turn-on/turn-off function of their supply pumps. Often these towers are in remote unmanned locations. The task is to maintain a constant safe volume of water in the tank without manually monitoring the water level.

Solution: An OMEGA pressure transducer, acting as the heart of the control system, monitors the water pressure at the base of the tank. The transducer signal is processed and then telemetered back to a control center miles away. The control decisions are made here based on the status information provided by the pressure transducer. The control is automatically or manually done to retain a constant safe water level in the tank. (See Figure 25A and 25B.)

Environment: Various temperature ranges from −20° to +110°F. Transducer diaphragm is also subject to water freeze-ups.

Pressure Characteristics: Pressure ranges are dependent upon height of water storage tank. Typically the water pressure is 35 psi. Often it is lower. For smaller tanks, it is under 10 psi. Pressure changes are gradual; however, there are large pressure spikes due to “water hammer” (short duration pressure pulses or shocks generated by a rapid change in flow rate).

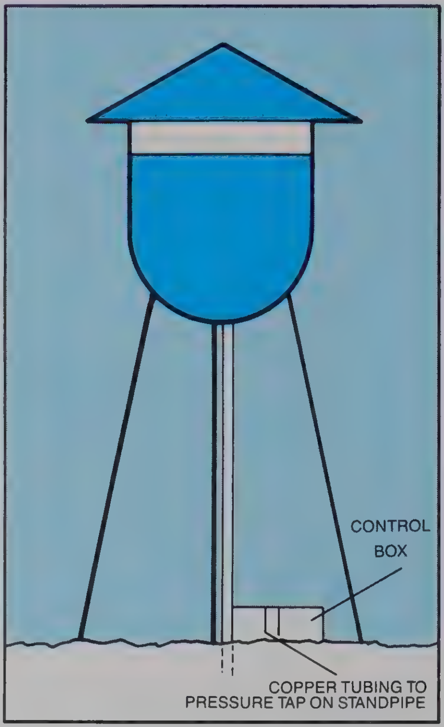


Figure 25A

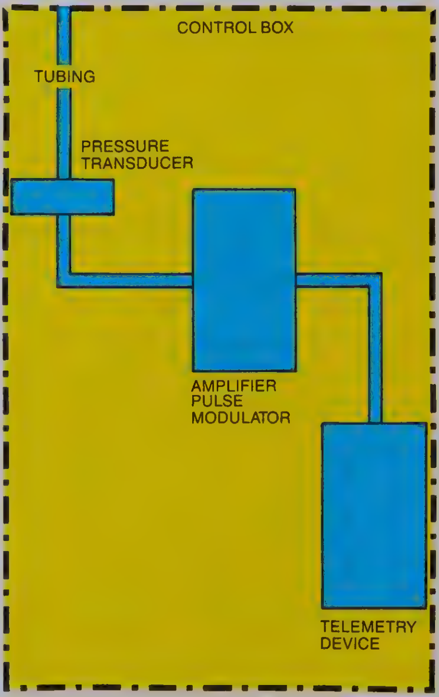


Figure 25B

DEEP SEA DIVING BELLS

Application: Measurement of pressures internal to, and external to, deep sea diving bells used in underwater construction of off-shore platforms and pipelines.

Problem: If divers can be held at deep sea pressures upon their return to the surface, their subsequent productivity can be increased greatly through the elimination of lengthy decompression procedures.

Solution: A diver enters his bell which is then lowered to working depth. Internal pressures on the first dive are increased to remain equal with external pressures. The diver leaves through a bottom lock, works and then returns. The lock is then sealed and the bell is raised. Internal pressures are maintained while external pressures decrease to atmospheric at the surface.

The diver then leaves the bell through another lock and enters a high pressure living chamber. He remains there until ready for the next dive when he re-enters the bell which is now already at (the same) high pressure. That these two pressures are equal is literally a matter of life or death.

Two OMEGA pressure transducers are mounted within the diving bell. The “outside” sensor measures the pressure in the ocean outside over a 0-1000 psis range. Its sealed construction permits safe operation and accurate readings. When it is back on deck and reads 0 psis, there may be as much as 1000 psig within the bell and on its outside case. The “inside” transducer measures the bell’s internal pressure and must also be sealed. (See Figure 26.)

Both sensors must be extremely accurate if the diver is able to leave the bell without danger of its flooding, and to enter and leave his living chamber without an abrupt and hazardous pressure change.

A Signal Conditioner accepts the transducer output and converts it to 4-20 mA for safe transmission back to the ship.

Environments: The transducer sees typical marine environments: high humidity, salt air, shipboard shock, small temperature changes during use, and no vibration.

Pressure Characteristics: Pressure changes are slow and consistent with the physiological system. The application is unique in that ambient pressures may be much higher than those measured—hence the need for a psis unit.

OIL TANKER PUMPS

Application: Monitoring of loading and unloading pumps mounted on deck of ocean going tanker.

Problem: Remote measurement of discharge pressure in loading and unloading operations provides crew with positive and centralized indication of pump performance.

Signal must be transmitted almost the length of the ship in extreme environments. Conditions are such to require Coast Guard approval for this equipment's usage in potentially explosive situations.

On-board tanks are sometimes at partial vacuum as they are emptied. The sensor must indicate this condition as well as normal pressures above ambient.

Solution: OMEGA PX-440 two wire transmitters are mounted in pipe "T"s on the discharge side of the pumps. They are wired back to the bridge in deck conduit where they are powered through an isolating barrier. A readout on the bridge reads pump pressures.

PX-440 absolute transducers are used — at normal atmospheric pressure they read 15% of full scale, thus permitting measurements into the vacuum region. The all-welded construction of the unit permits deck-top operation. See figure 27.

Environments: Brutal! Salt spray, occasional seawater, tropic to arctic temperatures, occasional shock, no significant vibration.

Pressure Characteristics: Pressure is steady with no significant spikes or surges.

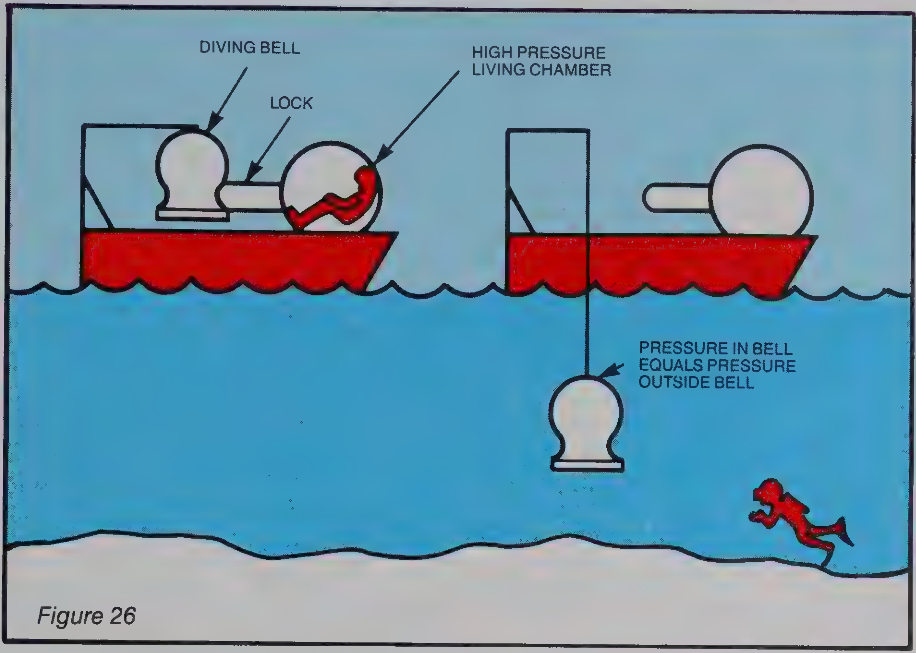

DIVING BELL
HIGH PRESSURE LIVING CHAMBER
LOCK
PRESSURE IN BELL EQUALS PRESSURE OUTSIDE BELL

Figure 26

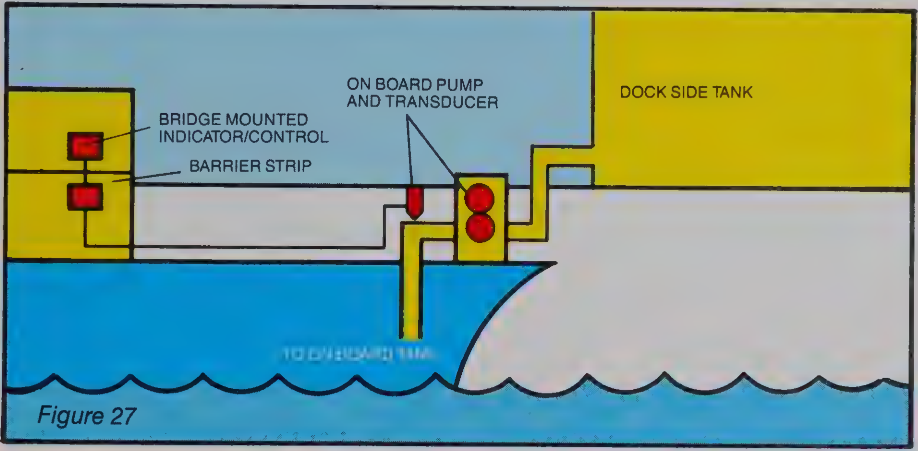

DOCK SIDE TANK
ON BOARD PUMP AND TRANSDUCER
BRIDGE MOUNTED INDICATOR/CONTROL
BARRIER STRIP
TO ON BOARD TANK

Figure 27

OIL WELL RE-CONDITIONING

Application: Customer "flushing" of old oil wells.

Problem: The bottom of a well and its surrounding strata can become clogged with residues which impede the flow of oil. By injecting various materials at high pressure (acid and/or steam, for example) the system is purged and the flow of product is restored.

The system can become plugged and pressure can rapidly build to dangerous levels. An automatic shutoff prior to rupture is necessary to insure the safety of operators and equipment.

Solution: An OMEGA PX-510 transducer is mounted in a "T" on the discharge of a high pressure, high volume, diesel driven pump.

Customer electronics permit presetting a maximum allowable pressure beyond which the pump is automatically turned off. The transducer's 0-5 V dc output permits signal transmission over long lines and remote location of the control box and system operator. See fig. 28.

Environments: The sensor assembly may be exposed to marine, desert, or arctic environments. Vibration is excessive due both to pump mounting and transportation by truck or helicopter. Media may contain sand, steam, acid, and petroleum wastes.

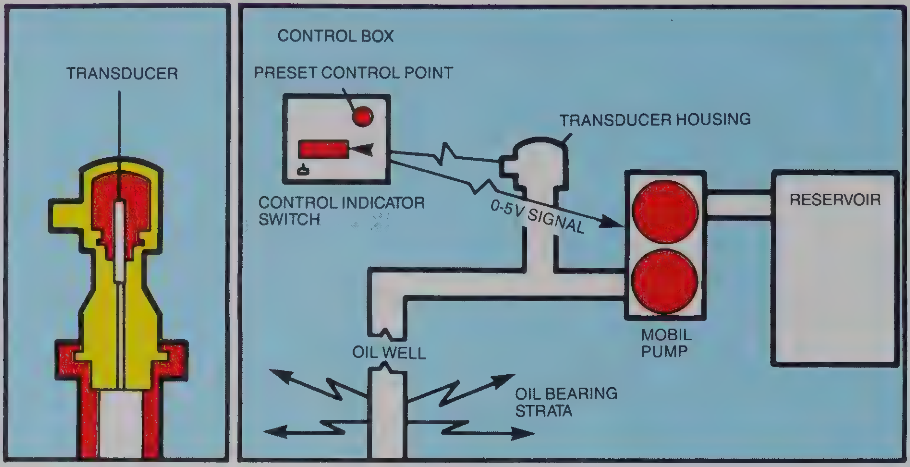

TRANSDUCER
CONTROL BOX
PRESET CONTROL POINT
TRANSDUCER HOUSING
CONTROL INDICATOR SWITCH
0-5V SIGNAL
RESERVOIR
MOBIL PUMP
OIL WELL
OIL BEARING STRATA

Figure 28

PIPELINE INSTRUMENTATION

Application: Liquid interface detector for pipelines.

Problem: Each liquid has unique "speed of sound" characteristics which will vary with both pressure and temperature. A "speed of sound" detector can differentiate between liquids in a pipeline when its readings are compensated for both pressure and temperature. Precise interface detection will prevent contamination and waste as product is transferred to storage tanks.

Solution: An OMEGA PX-102-2,000 transducer forms part of a sensor assembly which also includes a sound velocity and temperature transducer. The manufacturer's electronics package receives all three signals, "massages" the inputs, and produces an amplified and compensated "sound velocity" output for transmission to the receiver downstream. When a change in output is noted, operators are alerted to the imminent arrival of liquid interface. (See Figures 29A and 29B.)

Environments: Sensor assembly is mounted in outdoor environments from arctic to tropical (−60° to +60°C). It will see rain, snow, dust, and salt spray, but no particular shock or vibration.

Pressure Characteristics: Range 0-2000 psi with generally steady readings (no surge or spikes). Petroleum products (heavy oils, gasoline, kerosene) and seawater are the measured media.

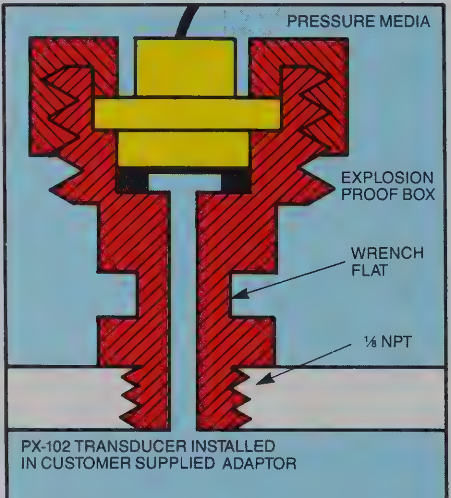

PRESSURE MEDIA
EXPLOSION PROOF BOX
WRENCH FLAT
⅛ NPT
PX-102 TRANSDUCER INSTALLED IN CUSTOMER SUPPLIED ADAPTOR

Figure 29A

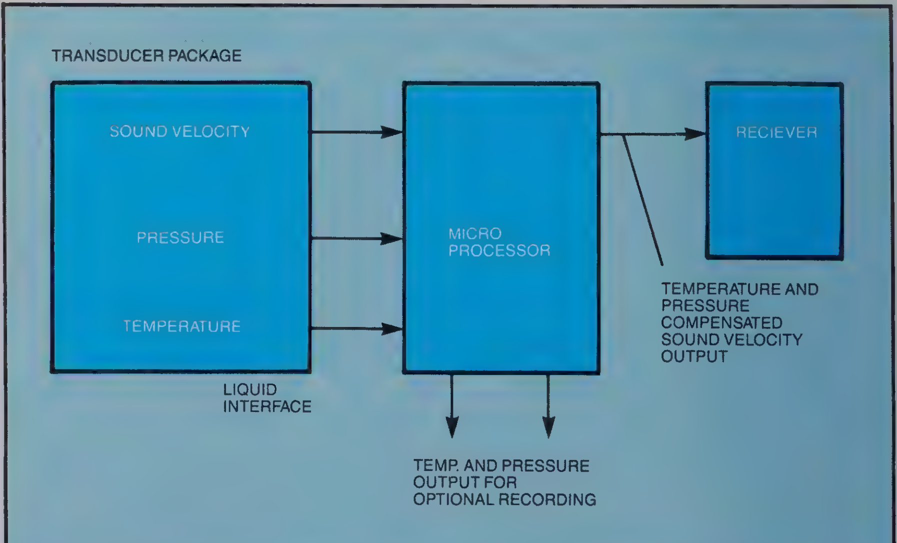

TRANSDUCER PACKAGE
SOUND VELOCITY
PRESSURE
TEMPERATURE
LIQUID INTERFACE
MICRO PROCESSOR
RECIEVER
TEMPERATURE AND PRESSURE COMPENSATED SOUND VELOCITY OUTPUT
TEMP. AND PRESSURE OUTPUT FOR OPTIONAL RECORDING

Figure 29B

SUBSEA PRODUCTION

Application: Measurement of wellhead pressures in subsea environments.

Problem: Oil wells on the ocean bottom are capped by a subsea production tree — an array of remotely operated valves and manifolds which control the wells' safety and production commonly referred to as a "Christmas Tree." Valves are hydraulically operated.

Pressures at the wellhead that must be monitored continuously include those within the tubing, annulus, and hydraulic system. They provide indication of the well's performance and also signal conditions which require automatic corrective action. Production trees are not available for routine servicing, and all measurements and systems must maintain reliable operation for years at the ocean's bottom.

For example, a rapid buildup in tubing pressure could signal a condition—unless counteracted—which could result in loss of product and hazardous surface conditions should a rupture occur.

Again, hydraulic system pressures must be known and maintained to produce correct valve operation with resulting proper safety and production.

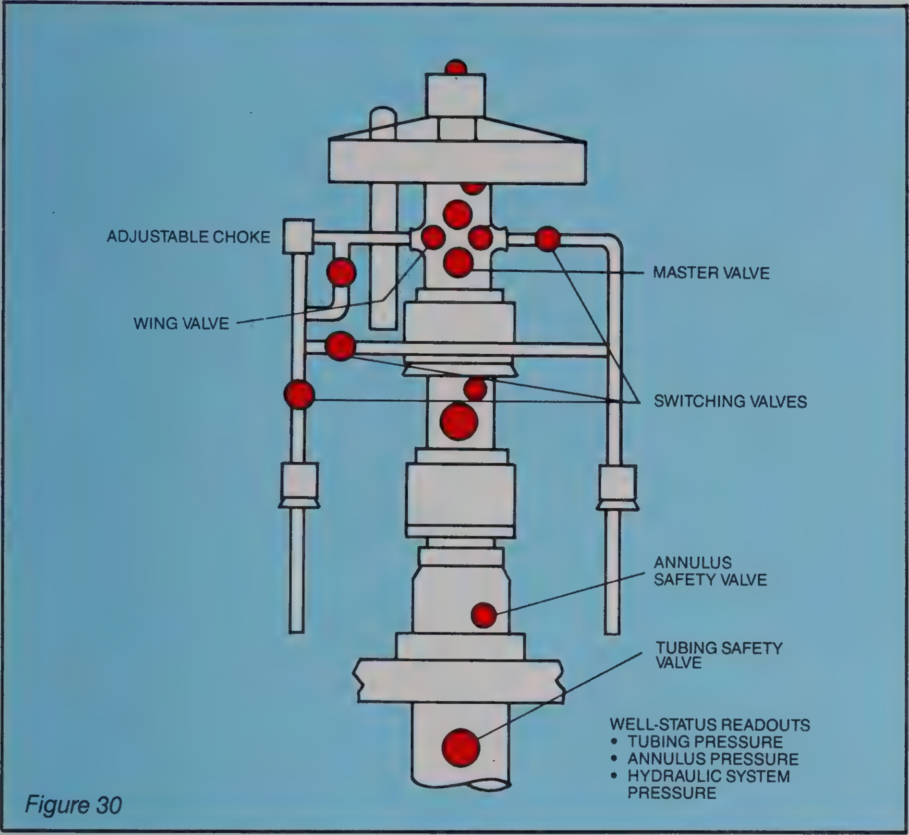

ADJUSTABLE CHOKE
WING VALVE
MASTER VALVE
SWITCHING VALVES
ANNULUS SAFETY VALVE
TUBING SAFETY VALVE
WELL-STATUS READOUTS
• TUBING PRESSURE
• ANNULUS PRESSURE
• HYDRAULIC SYSTEM PRESSURE

Figure 30

Solution: OMEGA PX-102 transducers are wet-lined directly to the annulus, tubing, and hydraulic supply. They are mounted in an enclosure that is otherwise hermetically sealed. Customer supplied electronics provide alarm, logging, and control functions. (See Figure 30.)

The two times over-range capabilities of the OMEGA PX-102 and its drift-free stability make it ideally suited for this demanding application.

Pressure Media: Hydraulic fluid, crude petroleum, seawater.

Environments: Sensors operate in a relatively stable and benign environment—even though at the bottom of the ocean.

BEVERAGE CAN COATING

Application: Control of paint spraying operation to insure uniform coating of inside of steel beverage cans.

Problem: Part of the steel beverage can-making operation includes spraying a lacquer coating inside of cans to prevent rusting and flavor change. Present visual method of inspection is inadequate because the coating is performed at the rate of 12,000 cans per hour. By the time a problem is observed, many cans have been miscoated. Two spraying problems occur: a clogged nozzle which stops spray altogether or sprays in blobs, and a worn nozzle which permits overcoating. With the present system, an additional bank of spraying machines is necessary to insure that every can is coated. This second coating adds time and expense to the operation.

Solution: A pressure transducer is inserted near the tip of a spray gun nozzle to monitor spraying pressures. Transducer output is fed into a multi-channel data acquisition/controller with one channel per spray head. (Typically five spray machines operate simultaneously.) The controller provides adjustable upper and lower set points with the upper limit set to indicate a clogged nozzle and the lower limit set to indicate a worn nozzle. When limits are exceeded, the system is immediately shut down. OMEGA controllers, modified with solid state switches to insure long life under high cyclic rates, are used in the system. (See Figure 31.)

Environment: High level electrical and environmental noise from surrounding machinery.

Pressure Characteristics: 0 to 1000 psi range. Upper control limit set at approximately 650 psi and lower limit at 550 psi.

Paint system is of the constant flow type with spray occurring when an electrical solenoid opens the nozzle. Because pressure in the nozzle drops after every spray pulse, the lower limit is constantly tripped. A microprocessor controls the system and permits shutdown only if limits are exceeded during actual spraying time (35 milliseconds).

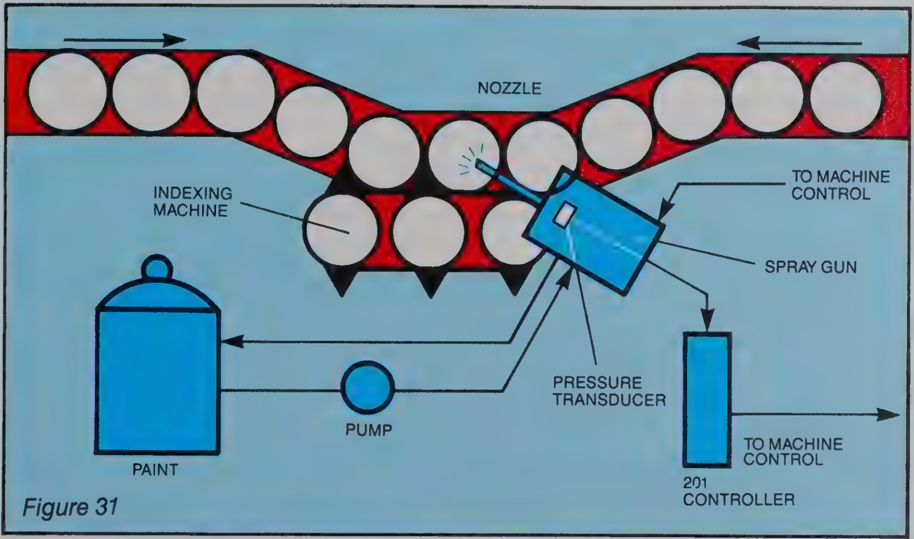

NOZZLE
INDEXING MACHINE
TO MACHINE CONTROL
SPRAY GUN
PAINT
PUMP
PRESSURE TRANSDUCER
TO MACHINE CONTROL
201 CONTROLLER

Figure 31

APPLICATION CONSIDERATIONS CONTINUED

IN THE PLASTICS INDUSTRY

Application: Measurement of pressures in the clamp mechanism and other hydraulic systems in plastic injection molding machines.

Problem: Customer had been using Bourdon-type pressure gages with the following problems:

(1) Gages were mounted at three locations on the machine which were selected for convenience of installation. Since the machines are twenty feet long, the operators did not walk around them to read the gages.

(2) In order to get the operators to read the pressures, the gages were all brought to the front of the machine by adding piping. This greatly increased the installation cost.

(3) Because the pressures were cycling at approximately 1 Hz, the Bourdon-type gages rapidly wore out. To save the gages, the manufacturer put a valve upstream of each one. The valve was to be turned off when the gage was not being read.

(4) Experience showed that the operators were either leaving the valves open or shut all the time. As a result, they were either wearing out the gages anyway or were not controlling the pressure properly. Also, the total cost of the system including gages, piping, valves, and frequent repairs was much more than the cost of the gage itself.

Solution: Two OMEGA PX-102 transducers and a special two-channel power supply and signal conditioner were supplied for each machine. The customer supplied a single panel meter with a selector switch so the operator could read either transducer at will. The switch and panel meter were mounted on the easily accessible control console.

In addition to longer life, the PX-102 system offered the industrial designers an opportunity to improve the appearance of the machine with better looking instrumentation.

Advantages:

1. Simpler installation
2. Remote reading
3. Ability to withstand millions of cycles without wearing out
4. Modern appearance of readout

LIQUID CHROMATOGRAPHS

Application: Control of liquid flow — high pressure, minimum volume.

Problem: Liquid is passed through a column packed with solid absorbent under conditions of high pressure and constant flow. This liquid consists of the sample to be analyzed and another carrier. The two liquids are mixed together prior to introduction to the column.

As the liquid goes through the column, the sample's components are selectively absorbed for subsequent analysis. Separation efficiency is dependent upon liquid flow rate at high pressures, typically in the region of 5000 psi.

Precise analysis requires that the system be kept to minimum volumes of known values. Liquids are often corrosive, sometimes extremely so.

Solution: An OMEGA PX-102 15,000 psi sensor is mounted in a customer designed flow chamber which is shown schematically. Transducer output to customer designed electronics regulates speed of metering pumps and hence flow rate from the chamber.

Note that: (1) the chamber is designed for minimum volume; (2) clamping is accomplished on the outer rim (non-responsive) of the transducer face; and (3) mixing of the sample and carrier take place at the transducer's face. (See Figures 32A and 32B.)

The materials normally encountered in this process are entirely compatible with the 15-5 ph stainless steel from which the PX-102 is made. Inconel-X transducers (psi specials) have been used successfully in some severely corrosive applications.

Environments: Environments are benign and have no vibration or shock. Temperatures are those of an air-conditioned laboratory.

Pressure Characteristics: Steady state with minimum "ripple".

WATER PIPE PRESSURE

Application: Monitoring of automatic sprinkler systems.

Problem: Under normal conditions a sprinkler system is under relatively steady static pressure. In the event the system "goes off", the pressure drops to a lower value as water is sprayed. A pressure drop in a particular segment of a total

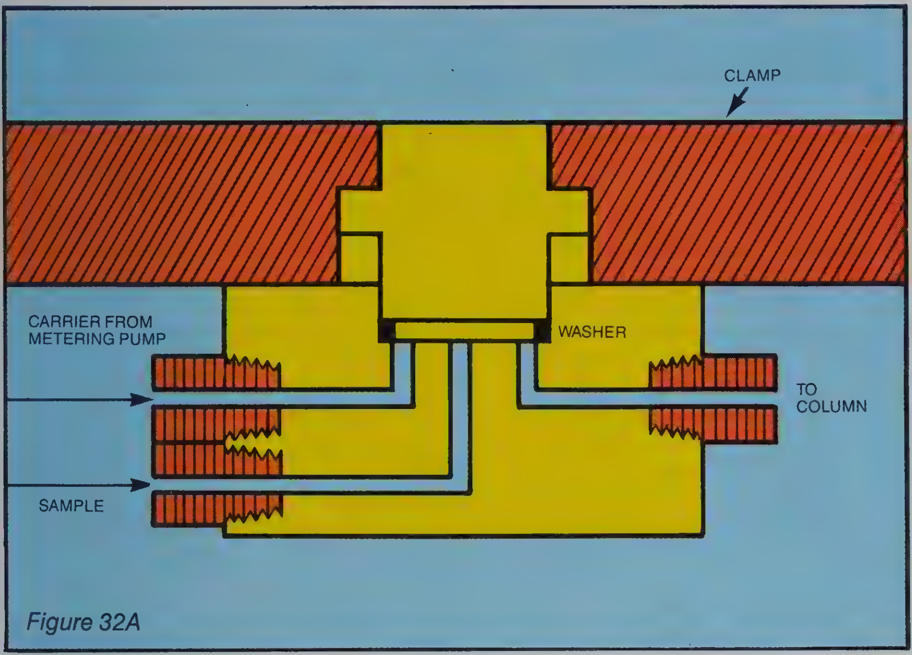


Figure 32A

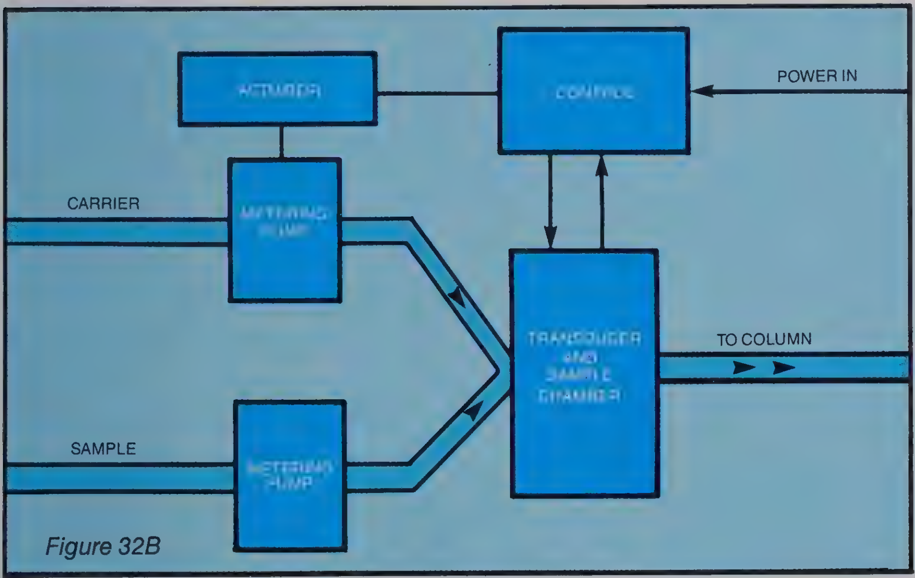


Figure 32B

building's system relative to the pressure in other segments will indicate a fire and its location—independent of fluctuations in normal building or municipal water pressure.

Scanning of pressure sensors in any particular building is done from a centralized scanner. When a particular transducer reports a lower reading, the scanner will show its building and station and thus direct firefighters to the correct location.

Due to the large number of stations and economic factors determining total system price, low cost is an important criterion in transducer selection.

Solution: An OMEGA pressure transducer is used as the basic pressure sensor in the customer's alarm package. Signal output is amplified and transmitted to a central system panel. When the panel is scanned, all sensor outputs are within nominal values of being identical if there is no water flow. If certain outputs fall, the scanner will sound an alarm and indicate specific transducer location for firefighters.

Automated production and testing of the OMEGA pressure transducers have made the selling price of these units such that the sales price of the customer's total package is economically acceptable.

Environments: Transducer will operate from −40° to +200°F although usage is generally within 0° to 150°F. Unit is enclosure mounted and sees no vibration or direct weather. Having a 0-200 psi range, it may see 350 psi without damage and up to 875 psi without bursting. These requirements are necessary due to the possibility of a "water hammer".

Pressure Characteristics: Normally steady rate to mildly fluctuating pressures are noted with occasional exposure to severe over-ranging resulting from a "water hammer".

HYDROELECTRIC TURBINE SYSTEMS

Application: Measurement of lube oil pressure in hydroelectric turbine generators.

Problem: Continual and steady flow of lube oil to turbine generators is necessary to insure efficient and safe operation. Remote indication and alarm are needed since turbines are often unattended.

Solution: OMEGA PX-440 pressure transducers are mounted in oil lines to turbine's main bearings and lube system. Signal conditioners power the transducers and transmit a 4-20 mA signal to the control room. Customer supplied indicator/alarm system will alert the operator immediately if oil pressure and flow depart from preset limits. Corrective action can then be initiated before the equipment is endangered.

Environments: Sensors are installed in the benign environments found in hydroelectric power stations.

Pressure Characteristics: Pressures generally range 50-60 psi, are steady and characteristic of those produced by a positive displacement pump. The only exceptions are in the rare event of leaking or breaking oil line (pressure drop) or plugged outlet (pressure rise).

PRESSURE REFERENCE SECTION
APPLICATION CONSIDERATIONS CONTINUED

HOW TO INTERPRET THE SPECIFICATIONS

In some cases the standard methods of specifying transducer performance may be difficult to translate into usable data. This section is for the purpose of clarifying this data to make it more useful.

AMBIENT TEMPERATURE REFERENCE

All specifications are referenced to an ambient temperature of 75°F. This means that the unit was calibrated at 75°F at the factory. As long as the ambient temperature remains at 75°F, there are no thermal effects.

ZERO BALANCE AND FULL SCALE OUTPUT

If, from one transducer to another at 75°F ambient temperature there was no tolerance on the output voltage at either zero or full rated pressure, the output line would start at zero with zero pressure and proceed to the full output voltage at full pressure. This is shown as a dotted line in Figure 33. Since there is a tolerance on the zero pressure voltage (called zero balance), the actual voltage at zero pressure can be above or below zero as depicted by the two solid lines on Figure 33.

There is also a tolerance on the voltage at full rated pressure (Full scale output voltage.) This results from a change in the slope of the output line (sensitivity) as illustrated in Figure 34.

Each individual transducer has particular zero pressure and full pressure voltages which remain constant at a constant ambient temperature, and to which the system in which the transducer is installed is calibrated. After system calibration the zero balance shift and output tolerance are of no consequence. Example, Series PX-301 Unit: 0—100 psi. Full scale output is 100 mV. The zero pressure output of any individual transducer will be at some constant value between the values of +1 mV to −1 mV. Assume it is actually +.05 mV. If there was no tolerance on the full scale output voltage, the output at 100 psi would be 100.05 mV. The tolerance on the full scale output, however, is ±1%. Therefore, the full output at 100 psi could be between 99.05 and 101.05 mV. Assume it is 101.05 mV. The system would then be calibrated to +.05 mV at zero pressure and 101.05 mV at 100 psi.

THERMAL EFFECTS

Thermal effects are the effects of ambient temperature changes. Ambient temperature affects both the zero pressure voltage (Thermal Zero Effect) and the slope of the output line (Thermal Sensitivity Effect). These effects are expressed in ± percentage changes of full scale output per degree F of ambient change. The percentages apply over the compensated range of +30° to +130°F. Figure 35 illustrates how these percentages relate to the total compensated range.

Figure 36 illustrates that with an ambient temperature change the zero pressure voltage and output line at 75° (from Figure 34) are changed. This is the Thermal Zero Effect. A corresponding change in the voltage at full pressure also occurs. At the same time a change in the output line slope occurs. This is called Thermal Sensitivity Effect as illustrated by Figure 37.

EXAMPLES

OMEGA Series PX-301 Unit: 0—100 psi. Full scale output 100 mV.

Assume the ambient temperature is 95°F when the unit is put into use and calibrated. Since the unit was factory calibrated at 75°F, a change in the zero pressure voltage which was calculated in the example under ZERO BALANCE (Figure 33) can be expected. This change is .02% full scale output per degree F. The ambient change is 20°F so the potential zero voltage change is ±.4% or ±.4 mV. Assume it is minus .4 mV. Referring to Figure 36, the zero pressure voltage and output line would be .4 mV below the zero pressure voltage and output line from Figure 34. Using the calculation from the previous examples, the Figure 36 zero pressure voltage is (+.05 −.4) or −.35, and the voltage at 100 psi would be (101.05 −.4) or 100.65. However, the voltage at 100 psi is also affected by the Thermal Sensitivity Effect. Assume this to be +.4 mV. Therefore the final value Figure 37 would be (100.65 +.40) or 101.05 mV at 100 psi. The zero pressure value would still be −.35 mV.

ACCURACY

Figure 38 illustrates that the combined effects of linearity, hysteresis and repeatability are related to the output lines that are achieved from either Figure 34 or 37 depending on whether there is any significant ambient temperature change. For the examples previously used, the repeatability is ±.5% full scale or ±.5 mV around the output line from Figure 37.

CONCLUSION

This section has been written to promote a better understanding of the use of the specifications. Although it is possible for the worst case to occur where all the factors accumulate in the same direction, this is very rare; in fact, experience shows that in the vast majority of cases the changes described tend to be more cancelling than additive. The result is a transducer which in all respects consistently meets the needs of the industrial market.

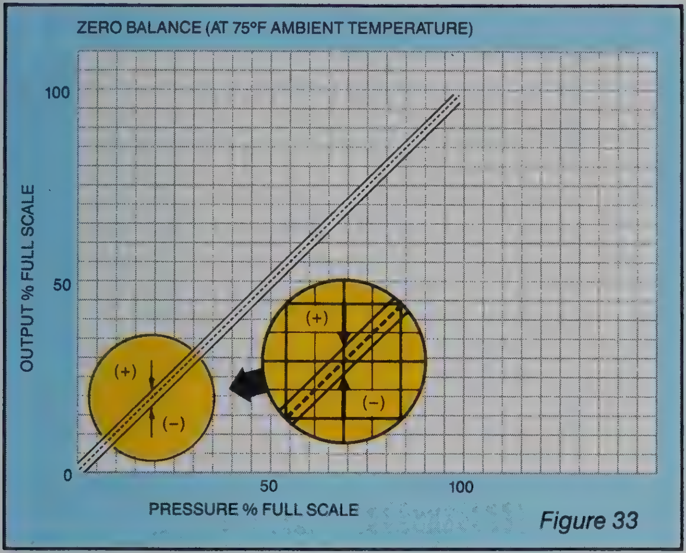


Figure 33

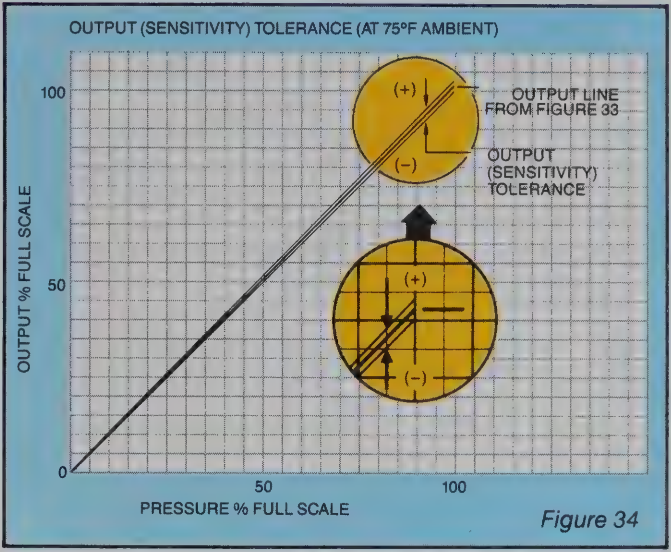


Figure 34

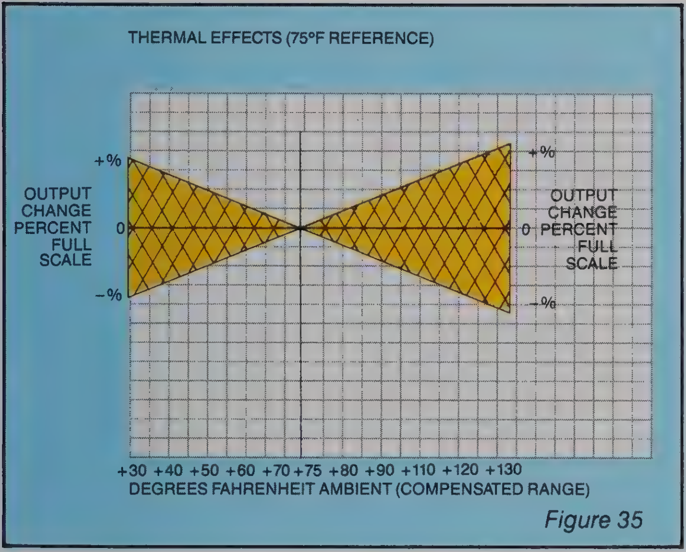


Figure 35

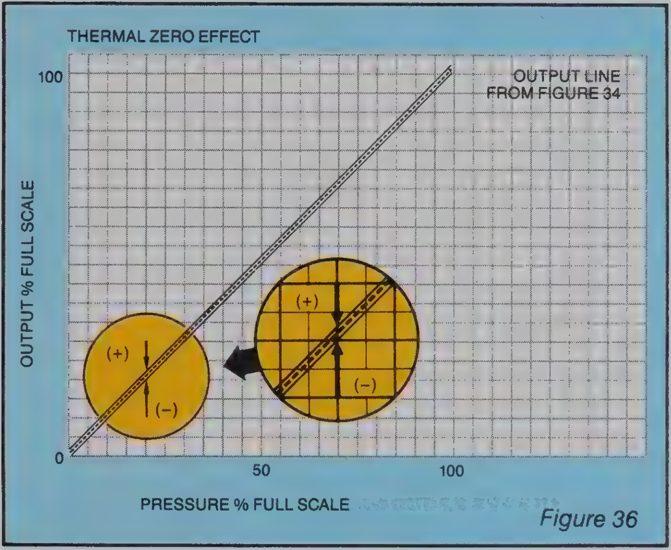


Figure 36

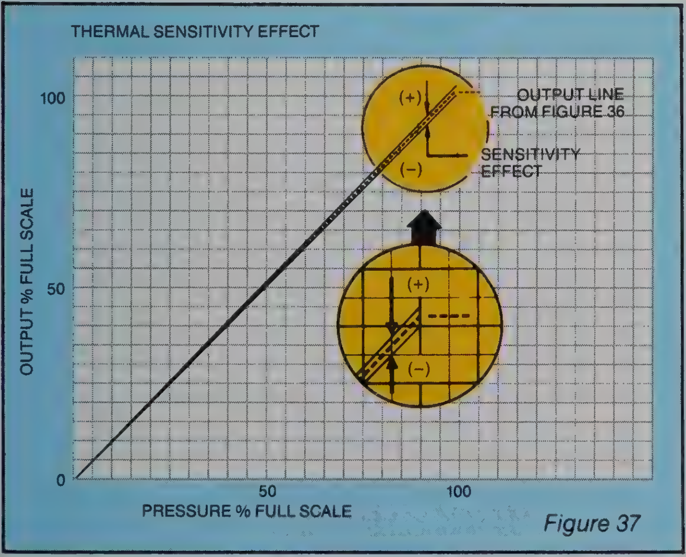


Figure 37

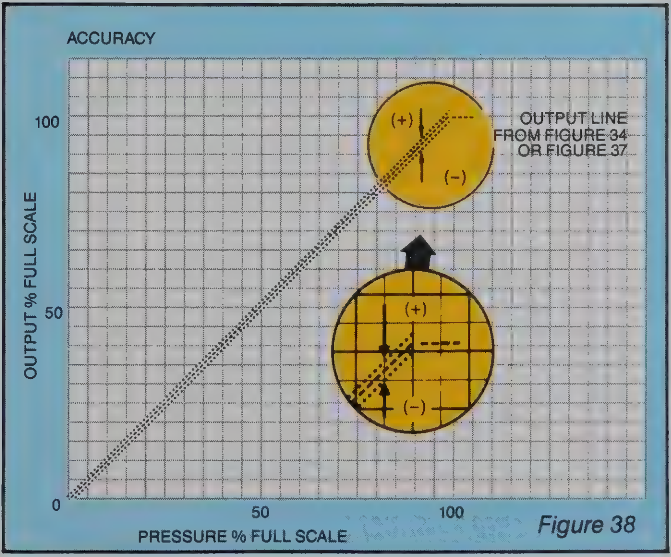
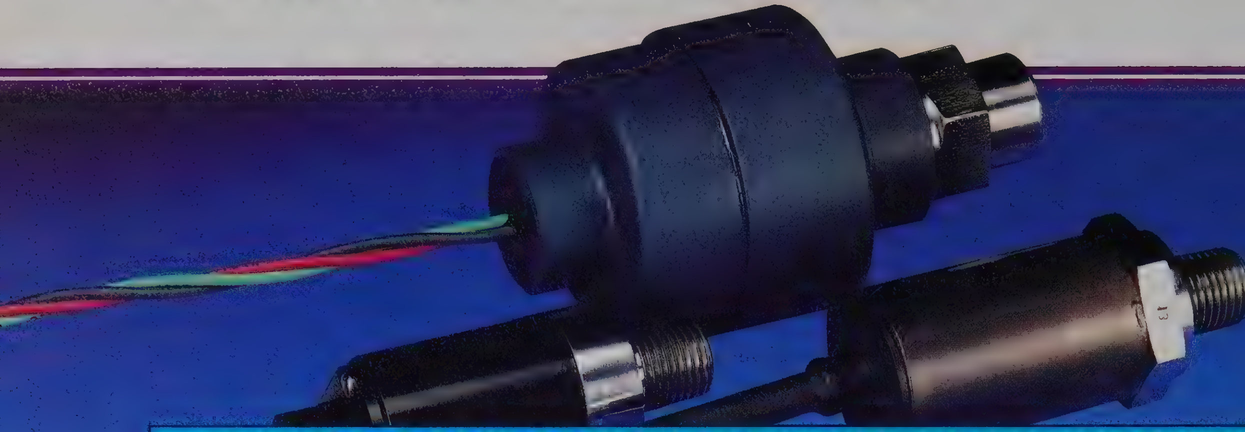


Figure 38

PRESSURE REFERENCE SECTION
TECHNICAL DATA SECTION



PRESSURE CONVERSION TABLE TO HELP IN APPLYING OMEGA® PRESSURE TRANSDUCERS

multiply no. of

to obtain ↓ / by ↘	Atmos	Bars	Dynes/ cm²	In of Hg (0°C)	In of H_2O (4°C)	K grams/ meter²	Lb/In² psi	Lb/ft²	mm of Hg torr	Microns	Pascals
Atmos	1	9.86923×10^{-1}	9.86923×10^{-7}	3.34207×10^{-2}	2.458×10^{-3}	9.678×10^{-5}	0.068046	4.7254×10^{-4}	1.316×10^{-3}	1.316×10^{-6}	9.869×10^{-6}
Bars	1.01325	1	10^{-6}	3.3864×10^{-2}	2.491×10^{-3}	9.8067×10^{-5}	6.8948×10^{-2}	4.788×10^{-4}	1.333×10^{-3}	1.333×10^{-6}	10^{-5}
Dynes/ cm²	1.01325×10^{6}	10^{6}	1	3.386×10^{4}	2.491×10^{3}	98.067	6.8948×10^{4}	478.8	1.333×10^{3}	1.333	10
In of Hg (0°C)	29.9213	29.53	2.953×10^{-5}	1	7.355×10^{-2}	2.896×10^{-3}	2.036	0.014139	3.937×10^{2}	3.937×10^{-5}	2.953×10^{-4}
In of H_2O (4°C)	406.8	401.48	4.0148×10^{-4}	13.60	1	3.937×10^{-2}	27.68	0.1922	0.5354	5.354×10^{-4}	4.014×10^{-3}
K grams/ meter²	1.033227×10^{4}	1.0197×10^{4}	1.0197×10^{-2}	345.3	25.40	1	7.0306×10^{2}	4.882	13.59	13.59×10^{-3}	1.019×10^{-1}
Lb/in² psi	14.695595	14.504	1.4504×10^{-5}	0.4912	3.6126×10^{-3}	1.423×10^{-3}	1	6.9444×10^{-3}	1.934×10^{-2}	1.934×10^{-5}	1.450×10^{-4}
Lb/ft²	2116.22	2088.5	2.0885×10^{-3}	70.726	5.202	0.2048	144.0	1	2.7844	2.7844×10^{-3}	2.089×10^{-2}
mm of Hg torr	760	750.06	7.5006×10^{-4}	25.400	1.868	7.3558×10^{-2}	51.715	0.35913	1	10^{-3}	7.502×10^{-3}
Microns	760×10^{3}	750.06×10^{3}	0.75006	2.54×10^{4}	1.868×10^{3}	73.558	51.715×10^{3}	359.1	1×10^{3}	1	7.502
Pascals	1.01325×10^{5}	1×10^{5}	10^{-1}	3.386×10^{3}	2.491×10^{2}	9.8067	6.8948×10^{3}	4.788×10^{1}	1.333×10^{2}	1.333×10^{-1}	1

TEMPERATURE CONVERSION CHART

°C	°F	°C	°F	°C	°F
– 200	– 328	0	32	140	284
– 180	– 292	5	41	160	320
– 160	– 256	10	50	180	356
– 140	– 220	15	59	200	392
– 120	– 184	20	68	212	414
– 100	– 148	25	77	220	428
– 90	– 130	30	86	250	482
– 80	– 112	40	104	300	572
– 70	– 94	50	122	350	662
– 60	– 76	60	140	400	752
– 50	– 58	70	158	450	842
– 40	– 40	80	176	500	932
– 30	– 22	90	194	600	1112
– 20	– 4	100	212	700	1292
– 10	+ 14	120	248	800	1472
				900	1652
				1000	1832

TEMPERATURE

$$°C = \frac{(F - 32)}{1.8}$$

$$°F = 1.8C + 32$$

METRIC

mm = 0.03937 in.
cm = 0.3937 in.
m = 39.37 in.

in. = 25.4 mm
in. = 2.54 cm
in. = 2.54×10^{-2} m

PRESSURE VS ALTITUDE

Altitude (Feet)	Pressure		
	in/Hg	mm/Hg	psi
– 1,000	31.02	787.9	15.25
– 500	30.47	773.8	14.94
0	29.921	760.0	14.70
500	29.38	746.4	14.43
1,000	28.86	732.9	14.18
1,500	28.33	719.7	13.90
2,000	27.82	706.6	13.67
2,500	27.31	693.8	13.41
3,000	26.81	681.1	13.19
3,500	26.32	668.6	12.92
4,000	25.84	656.3	12.70
4,500	25.36	644.2	12.45
5,000	24.89	632.3	12.23
10,000	20.58	522.6	10.10
15,000	16.88	428.8	8.28
20,000	13.75	349.1	6.75
30,000	8.88	225.6	4.36
40,000	5.54	140.7	2.72
50,000	3.426	87.30	1.689
60,000	2.132	54.15	1.048
70,000	1.322	33.59	0.649
80,000	0.820	20.83	0.403

SI: The Modernized Metric System

SI—the International System of Units—establishes the pascal (Pa) as the standard unit for Pressure or Stress in the modernized Metric System adopted by the American National Standards Institute.

To Convert to pascals	Multiply by
atmosphere	1.013×10^5
bar	1.000×10^5
dyne/centimeter^2	1.000×10^{-1}
inch of mercury (0°C)	3.386×10^3
inch of water (4°C)	2.491×10^2
kilogram/meter^2	9.806
pound/inch^2 (psi)	6.895×10^3
pound/foot^2	4.788×10^1
torr (mm of mercury 0°C)	1.333×10^2

PRESSURE CONVERSION CHART

psi	in./H_2O	in./Hg	mm/H_2O	mm/Hg	bar	mbar
.01	.2768	.0204	7.031	.5171	.0007	.6895
.02	.5536	.0407	14.06	1.034	.0014	1.379
.03	.8304	.0611	21.09	1.551	.0021	2.068
.04	1.107	.0814	28.12	2.068	.0028	2.758
.05	1.384	.1018	35.15	2.586	.0034	3.447
.06	1.661	.1222	42.18	3.103	.0041	4.137
.07	1.938	.1425	49.22	3.620	.0048	4.826
.08	2.214	.1629	56.25	4.137	.0055	5.516
.09	2.491	.1832	63.28	4.654	.0062	6.205
.10	2.768	.2036	70.31	5.171	.0069	6.895
.20	5.536	.4072	140.6	10.34	.0138	13.79
.30	8.304	.6108	210.9	15.51	.0207	20.68
.40	11.07	.8144	281.2	20.68	.0276	27.58
.50	13.84	1.018	351.5	25.86	.0345	34.47
.60	16.61	1.222	421.8	31.03	.0414	41.37
.70	19.38	1.425	492.2	36.20	.0483	48.26
.80	22.14	1.629	562.5	41.37	.0552	55.16
.90	24.91	1.832	632.8	46.54	.0620	62.05
1.0	27.68	2.036	703.1	51.71	.0690	68.95
2.0	55.36	4.072	1406	103.4	.1379	137.9
3.0	83.04	6.108	2109	155.1	.2068	206.8
4.0	110.7	8.144	2812	206.8	.2758	275.8
5.0	138.4	10.18	3515	258.6	.3447	344.7
6.0	166.1	12.22	4218	310.3	.4137	413.7
7.0	193.8	14.25	4922	362.0	.4826	482.6
8.0	221.4	16.29	5625	413.7	.5516	551.6
9.0	249.1	18.32	6328	465.4	.6205	620.5
10.0	276.8	20.36	7031	517.1	.6895	689.5
14.7	406.9	29.93	10340	760.2	1.014	1014
15.0	415.2	30.54	10550	775.7	1.034	1034
20.0	553.8	40.72	14060	1034	1.379	1379
25.0	692.0	60.80	17580	1293	1.724	1724
30.0	830.4	61.08	21090	1551	2.068	2068
40.0	1107	81.44	28120	2068	2.758	2758
50.0	1384	101.8	35150	2586	3.447	3447
100.0	2768	203.6	70310	5171	6.895	6895
150.0	4152	305.4	105500	7757	10.34	10340
200.0	5538	407.2	140600	10340	13.79	13790
250.0	6920	608.0	175800	12930	17.24	17240

Example: To convert 21.5 psi to mm/Hg. find the conversion factors for 20 psi (1034), 1.0 psi (51.71), and 0.5 psi (25.86). The sum of these factors is the mm/Hg value for 21.5 psi (1111.57/mm Hg).

CONVERSION FACTORS

PRESSURE

psi = (3.6127×10^{-2}) in. /H_2O

psi = (0.49118) in./Hg

psi = (1.4223×10^{-3}) mm/H_2O

psi = (1.9339×10^{-2}) mm/Hg

psi = (14.223×10^{-3}) cm/H_2O

psi = (14.224) kg/cm^2

psi = (14.503) bar

psi = (1.4503×10^{-2}) mbar

psi = (1.4504×10^{-4}) Pa

psi = (1.450×10^{-1}) kPa

in./H_2O = 27.68 psi

in./Hg = 2.036 psi

mm/H_2O = 703.1 psi

mm/Hg = 51.71 psi

cm/H_2O = 70.3 psi

kg/cm^2 = .0703 psi

bar = .0690 psi

mbar = 68.95 psi

Pa = 6895 psi

kPa = 6.895 psi

B PRESSURE TRANSDUCERS

OMEGA
ENGINEERING, INC.
FIELD TERMINALS

Resistance Bridge Type Transducers	B-3 Thru B-14
Flush Mount Transducer Adaptors	B-13
Amplified Output Type Transducers	B-15 Thru B-26
Process Loop Type Transducers	B-27 Thru B-37
Selection Guide	B-38 B-39 B-40

MINIATURE TRANSDUCERS FOR GAGE AND ABSOLUTE MEASUREMENT OF CLEAN GAS PRESSURES

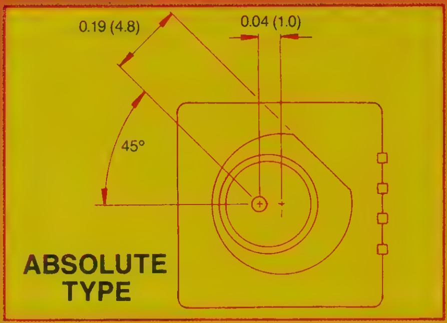
136 Series

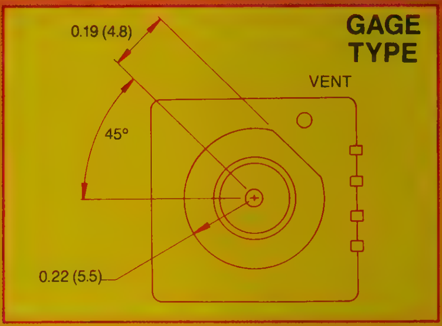
0-5 PSI 0-15 PSI

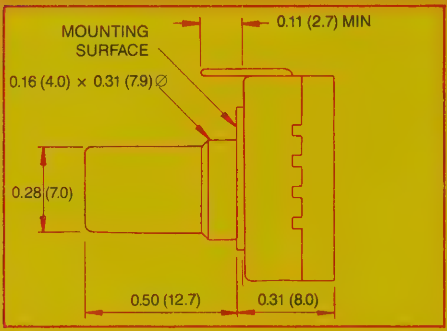
SILICON DIAPHRAGM

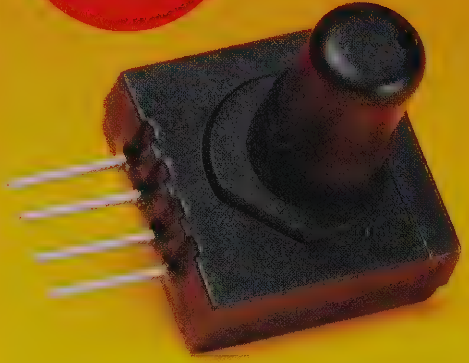
- Printed Circuit Mounting
- Miniature Package
- Temperature Compensated
- Linear Output
- 10 V dc Excitation
- Silicon Sensor
- Integral Diaphragm

From **$41**

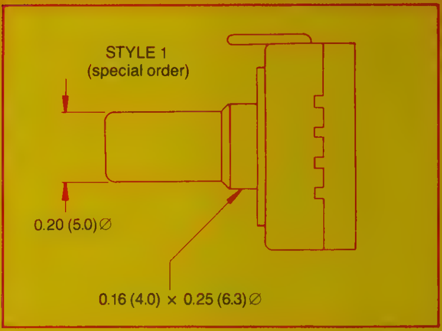

0.19 (4.8)
0.04 (1.0)
45°
ABSOLUTE TYPE

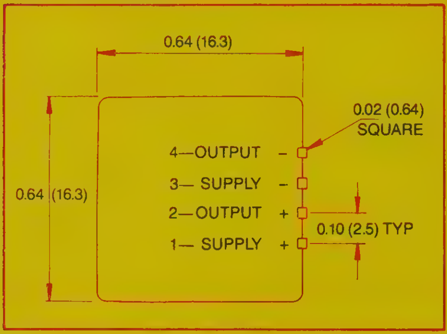

0.19 (4.8)
GAGE TYPE
VENT
45°
0.22 (5.5)

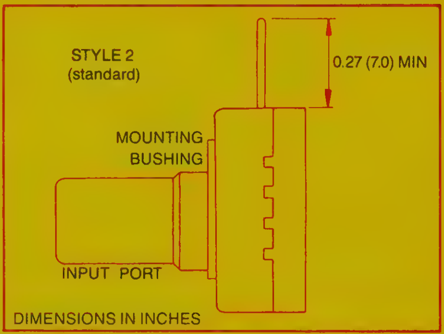

MOUNTING SURFACE
0.11 (2.7) MIN
0.16 (4.0) × 0.31 (7.9)∅
0.28 (7.0)
0.50 (12.7)
0.31 (8.0)

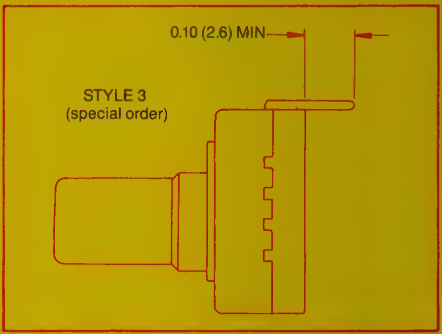


Shown twice actual size


STYLE 1
(special order)
0.20 (5.0)∅
0.16 (4.0) × 0.25 (6.3)∅


0.64 (16.3)
0.02 (0.64) SQUARE
4—OUTPUT −
3— SUPPLY −
2—OUTPUT +
1— SUPPLY +
0.64 (16.3)
0.10 (2.5) TYP


STYLE 2
(standard)
0.27 (7.0) MIN
MOUNTING BUSHING
INPUT PORT
DIMENSIONS IN INCHES


0.10 (2.6) MIN
STYLE 3
(special order)

The sensor is enclosed in a thermoplastic package equipped with standard spaced printed circuit board terminals. It is mounted through a hole in the panel, with a lockring to hold it in place.

SEE PAGE C-9 FOR TUBING

The sensing element in each transducer is a .100″ square silicon chip with integral sensing diaphragm and four piezoresistors. Pressure applied on the diaphragm causes it to flex, changing the resistance, which results in an output voltage proportional to pressure. The sensing resistors are connected as a four-active-element bridge for best linearity and sensitivity.

SEE PAGE C-3 FOR CONNECTORS

In absolute devices, the chamber is sealed, with a vacuum representing a fixed reference. The difference in pressure between the vacuum reference measurand applied at input causes the diaphragm to deflect, producing the output voltage change. Gage devices measure one pressure with respect to another. The chamber is vented to atmospheric pressure and the measurand is applied to the input.

To Order *(Specify model number)*

RANGE	OUTPUT	MODEL	PRICE
◆ 0-5 PSIG	50 mV	PX 136-005G V	$41 ◆
◆ 0-5 PSIG	100 mV	PX 136-015G V	41 ◆
◆ 0-15 PSIA	− 100 mV	PX 136-015A V	47 ◆

Note: Style 2 pins supplied as standard.

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

TO PLACE AN ORDER, CALL
OMEGA ENGINEERING, INC. (203) 359-1660

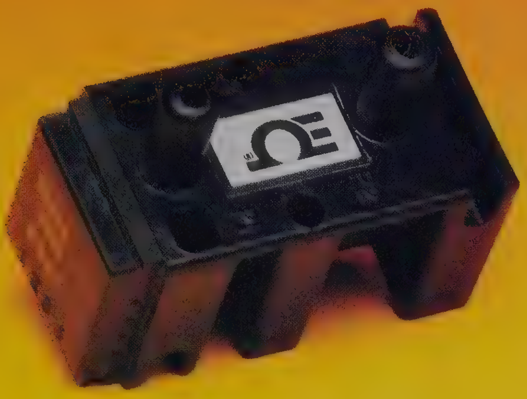
FOR DIFFERENTIAL MEASUREMENT OF CLEAN GAS PRESSURES

126 Series

0-5 PSI 0-15 PSI

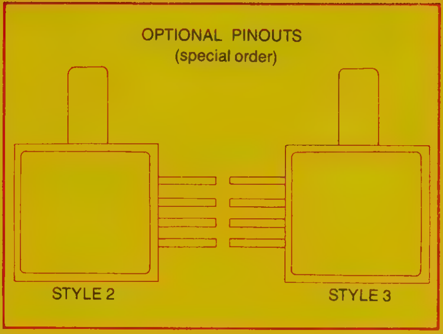
SILICON DIAPHRAGM

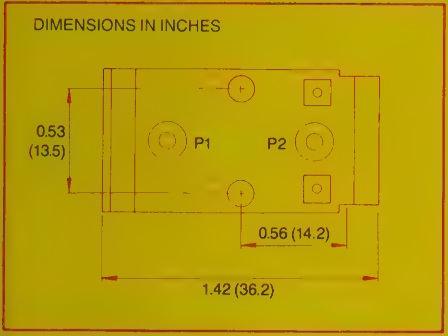
- Temperature Compensated
- Low Cost
- Fast Response
- Printed Circuit Mounting
- 50 & 100 mV Outputs
- 10 V dc Excitation
- −55 to +125°C
- Heavy Duty Plastic Case

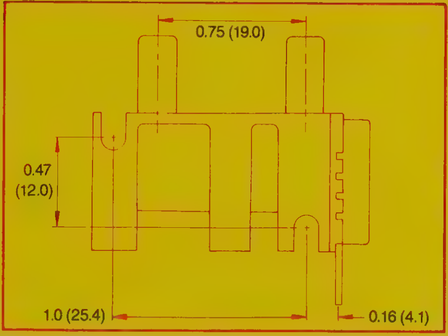


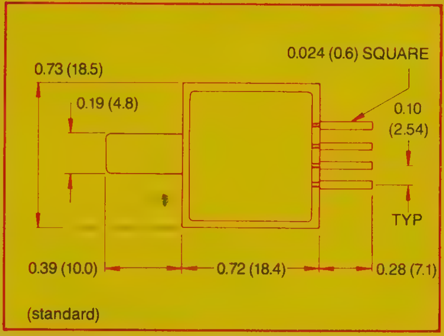
$41

Shown slightly larger than actual size


OPTIONAL PINOUTS
(special order)
STYLE 2
STYLE 3


DIMENSIONS IN INCHES
0.53
(13.5)
P1
P2
0.56 (14.2)
1.42 (36.2)


0.75 (19.0)
0.47
(12.0)
1.0 (25.4)
0.16 (4.1)


0.73 (18.5)
0.024 (0.6) SQUARE
0.19 (4.8)
0.10
(2.54)
TYP
0.39 (10.0)
0.72 (18.4)
0.28 (7.1)
(standard)

SOLID STATE

120 PC pressure transducers are solid state piezoresistive devices ideally suited to applications requiring exact measurement of pressure, where the benefits of repeatability, low hysteresis, and long term stability are important. This series offers the traditional benefits of solid state, including small size, ruggedness and reliability. These differential types are available in two pressure ranges (0-5, 0-15 psi). The sensor is enclosed in a black thermoplastic package, equipped with standard spaced printed circuit board terminals.

The heart of each device is a .10″ square silicon sensor chip. The sensing diaphragm and piezoresistors are integral parts of the chip. Pressure applied on the diaphragm causes it to flex, changing the resistance, which results in an output voltage proportional to pressure.

Pressure may be applied to both sides of the sensing chip. P1 is the termination side, and only relatively clean gases such as air are recommended as measureands on this side. Fewer restrictions apply to the P2 side, except that media incompatible with RTV, silicon, or polyester should not be used.

To Order *(Specify model number)*

RANGE	OUTPUT	MODEL	PRICE
▶ 5 PSID	50 mV	PX 126-005D V	$41 ◀
▶ 15 PSID	100 mV	PX 126-015D V	41 ◀

▶ *HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY* ◀

HALF BRIDGE FOR ECONOMY

300 Series
0-150 to 0-7,000 PSIG

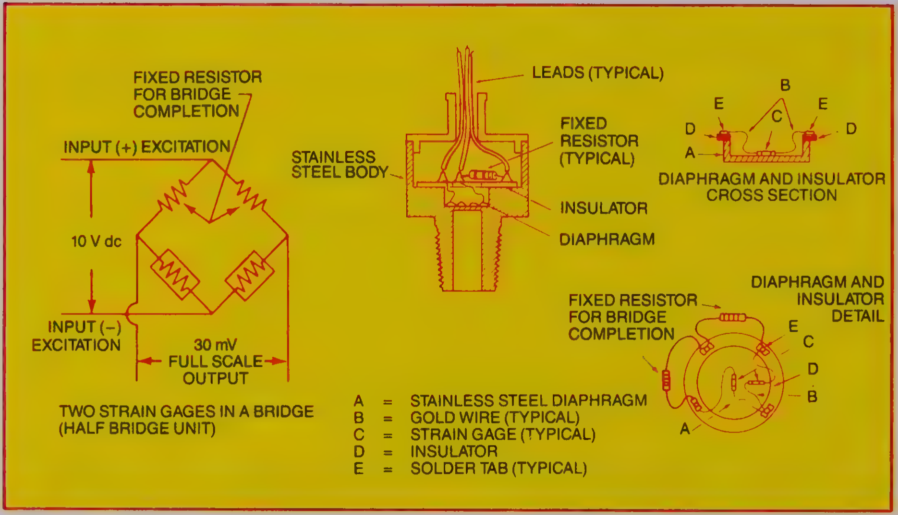
- **30 mV FS Output**
- **Heavy Duty Stainless Steel Housing**
- **¼ NPT Fitting for Secure Installation**
- **Integral Strain Relief on Cable**

Supplied with 36" of 22 Gage Lead Wire

$98

Shown actual size

SEE SECTION D FOR COMPLETE INSTRUMENTATION


FIXED RESISTOR FOR BRIDGE COMPLETION
INPUT (+) EXCITATION
10 V dc
INPUT (–) EXCITATION
30 mV FULL SCALE OUTPUT
TWO STRAIN GAGES IN A BRIDGE (HALF BRIDGE UNIT)
STAINLESS STEEL BODY
LEADS (TYPICAL)
FIXED RESISTOR (TYPICAL)
INSULATOR
DIAPHRAGM
E
B
C
E
D
D
A
DIAPHRAGM AND INSULATOR CROSS SECTION
FIXED RESISTOR FOR BRIDGE COMPLETION
DIAPHRAGM AND INSULATOR DETAIL
E
C
D
B
A
A = STAINLESS STEEL DIAPHRAGM
B = GOLD WIRE (TYPICAL)
C = STRAIN GAGE (TYPICAL)
D = INSULATOR
E = SOLDER TAB (TYPICAL)

To Order *(Specify model number)*

RANGE	MODEL	PRICE
◆ 0- 150 PSIG	PX 300-150G V	$98 ◆
◆ 0- 500 PSIG	PX 300-500G V	98 ◆
◆ 0-1000 PSIG	PX 300-1 KG V	98 ◆
0-1500 PSIG	PX 300-1.5KG V	98
0-3000 PSIG	PX 300-3 KG V	98
◆ 0-5000 PSIG	PX 300-5 KG V	98 ◆
0-7000 PSIG	PX 300-7 KG V	98

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

Pressure Transducers utilize semiconductor gages which are epoxy bonded to a metal diaphragm. Pressure applied to the diaphragm through the pressure port produces a minute deflection which introduces strain to the gages. The strain produces an electrical resistance change proportional to the pressure. Four gages (or 2 gages with fixed resistors) form a Wheatstone Bridge.

SPECIFICATIONS

Excitation: Nominal 10 volts DC
Output: 30 mV full scale ±1 mV (Nominal 3 mV/V)
Proof Pressure: 2 x full scale
Input Impedance: 1000 ohms minimum
Output Impedance: 120 ohms nominal

PERFORMANCE

Accuracy: ±0.5% of full scale at +75°F (Includes linearity, hysteresis, and repeatability)
Zero Balance: ±1 mV at +75°F
Compensated Temp. Range: +30°F to +110°F
Thermal Zero Effect: ±.03%/deg. F over compensated temperature range
Thermal Span Effect: ±.06%/deg. F over compensated temperature range
Operable Temperature Range: –20°F to +140°F

FULL BRIDGE FOR ACCURACY

302 Series
0-50 to 0-5,000 PSIG

- 100 mV FS Output
- Heavy Duty Stainless Steel Housing
- Integral Strain Relief

$136

Supplied with 36" of 22 Gage Lead Wire

Shown actual size

SEE PAGE C-13 FOR ADAPTOR BUSHINGS TO FIT YOUR SYSTEM.

The differential resistance is measured by applying a constant voltage to the bridge. Diaphragm deflection results in an analog (millivolt) output which is proportional to the pressure.

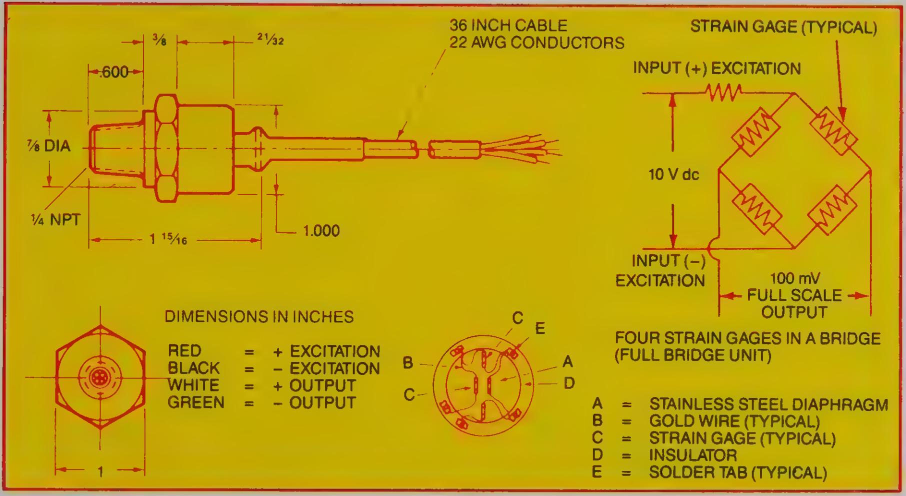
Fixed resistors are used for bridge completion (in half bridge units), temperature compensation, zero balance, and to achieve full scale output.

SPECIFICATIONS

Excitation: Nominal 10 volts DC
Output: 100 mV full scale (10 mV/V ±1%)
Proof Pressure: 2 x full scale or 15,000 psi (whichever is less)
Input Impedance: 1200 ohms minimum
Output Impedance: 500 ohms nominal

PERFORMANCE

Accuracy: ±0.5% of full scale at 75°F (linearity, hysteresis, and repeatability)
Zero Balance: ±2% of full scale at +75°F
Compensated Temp. Range: +30°F to +130°F standard
Thermal Zero Effect: ±.03%/deg. F over compensated temperature range
Thermal Span Effect: ±.03%/deg. F over compensated temperature range
Operable Temperature Range: −20°F to +140°F



DIMENSIONS IN INCHES

RED = + EXCITATION
BLACK = − EXCITATION
WHITE = + OUTPUT
GREEN = − OUTPUT

FOUR STRAIN GAGES IN A BRIDGE (FULL BRIDGE UNIT)

A = STAINLESS STEEL DIAPHRAGM
B = GOLD WIRE (TYPICAL)
C = STRAIN GAGE (TYPICAL)
D = INSULATOR
E = SOLDER TAB (TYPICAL)

To Order *(Specify model number)*

RANGE	MODEL	PRICE
◆ 0- 50 PSIG	PX 302-050G V	$136 ◆
◆ 0- 100 PSIG	PX 302-100G V	136 ◆
0- 150 PSIG	PX 302-150G V	136
◆ 0- 300 PSIG	PX 302-300G V	136 ◆
◆ 0- 500 PSIG	PX 302-500G V	136 ◆
0- 1000 PSIG	PX 302- 1 KG V	136
◆ 0- 1500 PSIG	PX 302- 1.5KG V	136 ◆
◆ 0- 3000 PSIG	PX 302- 3 KG V	136 ◆
◆ 0- 5000 PSIG	PX 302- 5 KG V	136 ◆

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

STAINLESS STEEL HOUSED GAGE PRESSURE TRANSDUCER
WITH ¼-18 NPT PORT

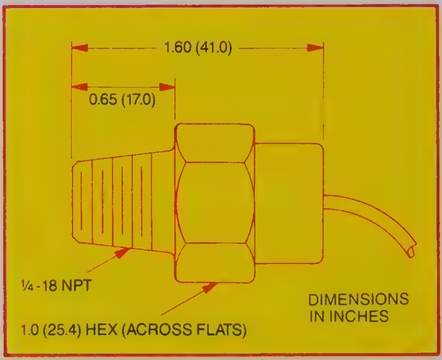
230 Series

0-15 PSIG
0-30 PSIG
0-60 PSIG
0-100 PSIG

SILICON DIAPHRAGM
- 18″ Leads Standard
- Compensated
- ¼-18 NPT Pressure Port
- 1 Millisecond Response Time
- −30° to 70°C Operation
- 10 V dc Excitation

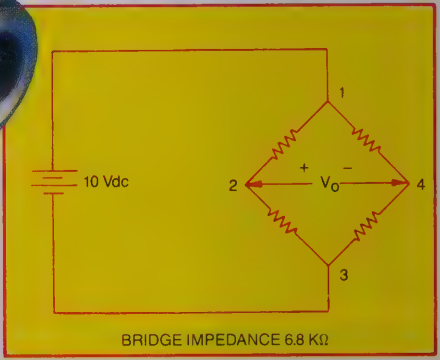
$67

Shown twice actual size



LEADWIRES

1-Red	V_S
2-White	Out +
3-Black	V_R
4-Green	Out −



The sensor is enclosed in a stainless steel housing with a thermoplastic cover which provides integral strain relief for the termination cable. The remote atmospheric pressure reference is inside the termination cable, reducing the chances of contaminants entering the sensor enclosure. The pressure medium can be liquid or gaseous, so long as it does not react with silicon, glass, 300 series stainless steel, or urethane based epoxy.

The sensing element is a .100″ square silicon chip with integral sensing diaphragm and four piezoresistors. Pressure applied on the diaphragm causes it to flex, changing the resistance, which results in an output voltage proportional to pressure. The sensing resistors are connected as a four-active-element bridge for best linearity and sensitivity.

To Order *(Specify model number)*

RANGE	OUTPUT	MODEL	PRICE
0 to 15 PSIG	100 mV	PX 236-015G V	**$67**
0 to 30 PSIG	75 mV	PX 236-030G V	67
▶ 0 to 60 PSIG	60 mV	PX 236-060G V	67 ◀
▶ 0 to 100 PSIG	100 mV	PX 236-100G V	67 ◀

▶ *HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY* ◀

100 mV STRAIN GAGE OUTPUT
STAINLESS STEEL DIAPHRAGM

304 Series
0-50 to 0-300 PSIA

Bonding Method Provides Excellent Long Term Stability

The strain gages are epoxy bonded to a precision metal diaphragm, the thickness of which determines the pressure range of the transducer. The proprietary bonding method, coupled with the diaphragm design and metal finish, results in excellent long term stability.

- **Precise Absolute Pressure Measurement**
- **Corrosion Resistant Type 17-4 PH Stainless Steel Construction**

Not shown actual size

$240

Absolute Pressure

SPECIFICATIONS

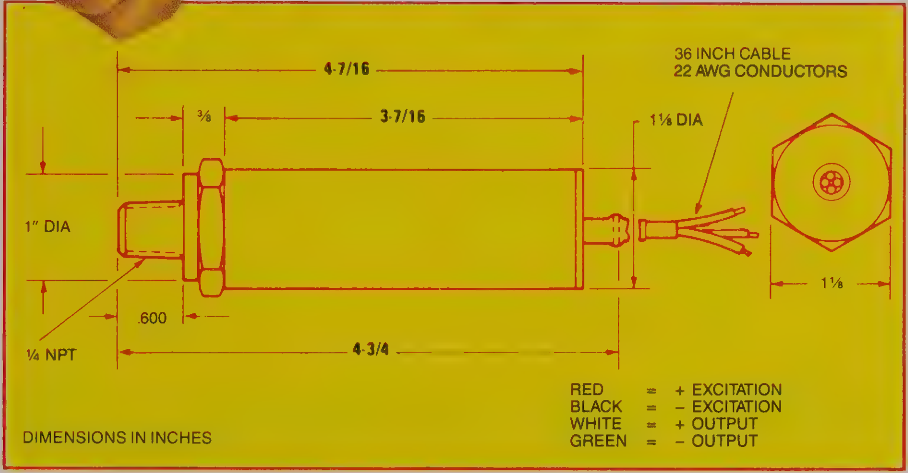
Excitation: Nominal 10 volts DC
Output: 100 mV full scale (10 mV/V ±1%)
Proof Pressure: 2 x full scale or 15,000 psi (whichever is less)
Input Impedance: 1200 ohms nominal
Output Impedance: 500 ohms nominal

PERFORMANCE

Accuracy: ±0.5% of full scale at 75°F (linearity, hysteresis, and repeatability)
Zero Balance: ±2% of full scale at +75°F
Output Tolerance (Sensitivity): ±1% of full scale at +75°F
Compensated Temp. Range: +30°F to +130°F standard
Thermal Zero Effect: ±.02%/deg. F (over compensated temperature range)
Thermal Span Effect: ±.02%/deg. F (over compensated temperature range)
Operable Temperature Range: −20 to +140°F

CONSTRUCTION

Body Diaphragm Material: 17-4 PH stainless steel
Pressure Port: ¼-18 NPT standard
Electrical Connections: See installation outline
Pressure Cavity Volume: .0687 cubic inches



RED = + EXCITATION
BLACK = − EXCITATION
WHITE = + OUTPUT
GREEN = − OUTPUT

DIMENSIONS IN INCHES

To Order *(Specify model number)*

RANGE	MODEL	PRICE
◆ 0- 50 PSIA	PX 304-050A V	**$240** ◆
0-100 PSIA	PX 304-100A V	240
◆ 0-150 PSIA	PX 304-150A V	240 ◆
0-300 PSIA	PX 304-300A V	240

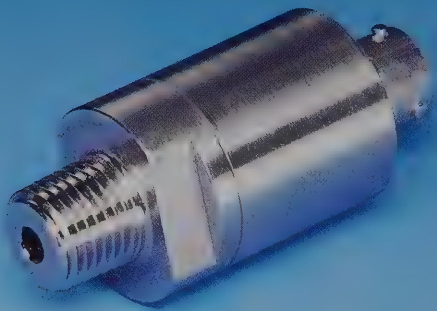
◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

HEAVY DUTY STAINLESS STEEL CASE
GENERAL PURPOSE APPLICATIONS

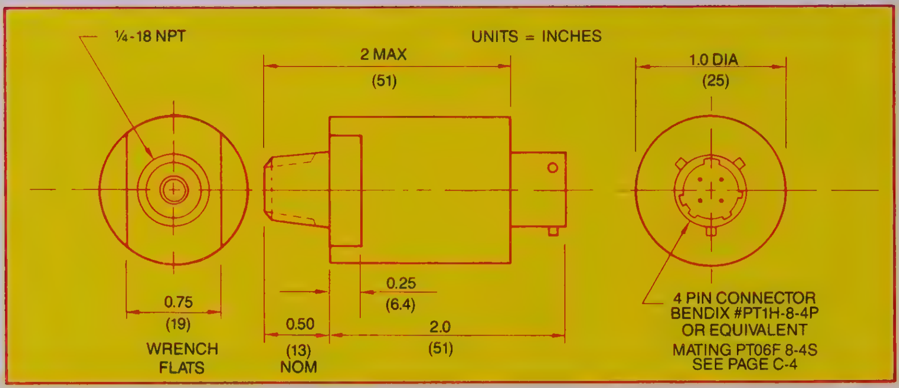
100 Series
0-15 to 0-5000 PSIG

- Stainless Steel Diaphragm
- Compact Design for Restricted Areas
- Quick Disconnect Feature
- Accurate Low Level Output

From
$175



Shown actual size



To Order *(Specify model number)*

RANGE	MODEL	PRICE
0- 15 PSIG	PX 100-015G V	$190
◆ 0- 30 PSIG	PX 100-030G V	190 ◆
0- 50 PSIG	PX 100-050G V	190
◆ 0- 100 PSIG	PX 100-100G V	175 ◆
0- 200 PSIG	PX 100-200G V	175
◆ 0- 500 PSIG	PX 100-500G V	175 ◆
0-1000 PSIG	PX 100-1KG V	175
◆ 0-2000 PSIG	PX 100-2KG V	175 ◆
0-5000 PSIG	PX 100-5KG V	175

◆ *HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY* ◆

The Model PX 100 is a small, rugged pressure transducer which utilizes a silicon strain gage bridge bonded to a flat diaphragm to measure low-level pressure-induced diaphragm deflections. The pressure cavity is manufactured from a solid machined piece of 17-4PH stainless steel. This all-one-piece construction eliminates leaks and makes Model PX100 ideal for use with a wide variety of corrosive fluids under adverse environmental conditions.

SPECIFICATIONS

Excitation: 10 V dc
Output: 10 mV/V ±1%
Proof Pressure: 2 x full scale
Input Impedance: 500 ohms minimum
Output Impedance: 500 ohms nominal

PERFORMANCE

Accuracy: ±0.5% of full scale at +75°F (Includes linearity, hysteresis, and repeatability)
Zero Balance: ±1.0% FS
Compensated Temp. Range: 0 to +130°F
Thermal Zero Effect: ±0.01% FS/°F
Thermal Span Effect: ±0.01% FS/°F
Operable Temperature Range: −65°F to +255°F

HEAVY DUTY STAINLESS STEEL CASE
GENERAL PURPOSE APPLICATIONS

301 Series
0-50 to 0-5,000 PSIG

- **Stainless Steel Diaphragm**
- **High Input Impedance**
- **Supplied with 36 inch, 22 Gage Lead Wire**

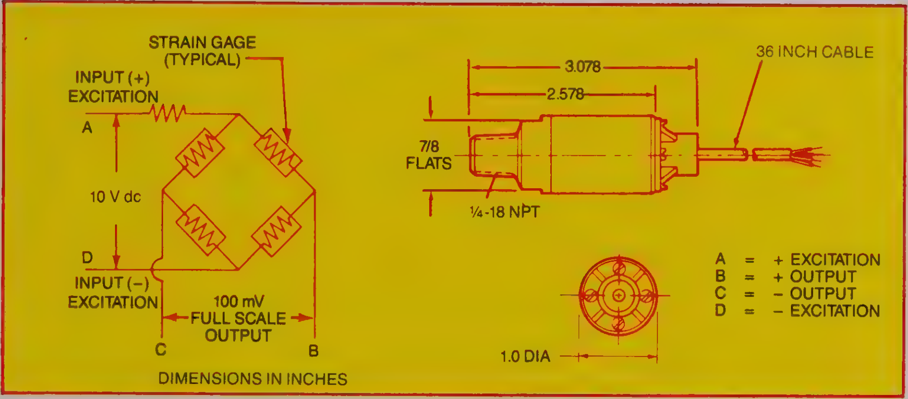
$180

Shown actual size

SPECIFICATIONS
Excitation: Nominal 10 V dc
Output: 100 mV full scale (10 mV/V ±1%)
Proof Pressure: 2x full scale or 15,000 psi (whichever is less)
Input Impedance: 1200 ohms minimum
Output Impedance: 500 ohms nominal

PERFORMANCE
Accuracy: ±0.5% full scale at 75°F (linearity, hysteresis, and repeatability)
Zero Balance: ±2% of full scale at +75°F
Compensated Temp. Range: +30 to +130°F standard
Thermal Zero Effect: ±.02%/°F (over compensated temperature range)
Thermal Span Effect: ±.02%/°F (over compensated temperature range)
Operable Temperature Range: −50 to 225°F

CONSTRUCTION
Body/Diaphragm Material: 17-4 PH stainless steel
Pressure Port: Male ¼-18 NPT
Cavity Volume: .0687 cubic inches


STRAIN GAGE (TYPICAL)
INPUT (+) EXCITATION
A
10 V dc
D
INPUT (−) EXCITATION
100 mV FULL SCALE OUTPUT
C
B
3.078
2.578
36 INCH CABLE
7/8 FLATS
¼-18 NPT
1.0 DIA
A = + EXCITATION
B = + OUTPUT
C = − OUTPUT
D = − EXCITATION
DIMENSIONS IN INCHES

To Order *(Specify model number)*

RANGE	MODEL	PRICE
◆ 0- 50 PSIG	PX 301-050G V	$180 ◆
◆ 0- 100 PSIG	PX 301-100G V	180 ◆
0- 300 PSIG	PX 301-300G V	180
0- 500 PSIG	PX 301-500G V	180
0- 750 PSIG	PX 301-750G V	180
◆ 0- 1000 PSIG	PX 301- 1 KG V	180 ◆
0- 2000 PSIG	PX 301- 2 KG V	180
◆ 0- 4000 PSIG	PX 301- 4 KG V	180 ◆
◆ 0- 5000 PSIG	PX 301- 5 KG V	180 ◆

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

MODEL R15P250
SERIAL NO PS 1283
CALIBRATION 5V @ 500 mA
AMPS
VOLTAGE 110
OMEGA ENGINEERING, INC. Stamford, CT 06907

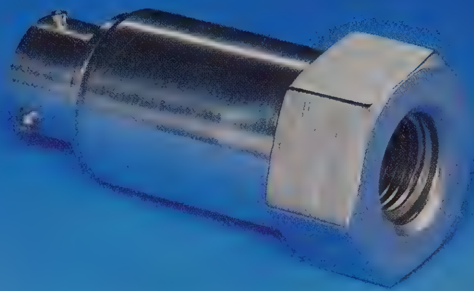
POWER SUPPLIES PAGE C-7

SMALL SIZE WIDE RANGE FEMALE PORT

306 Series
0-300 to 0-7,500 PSIG

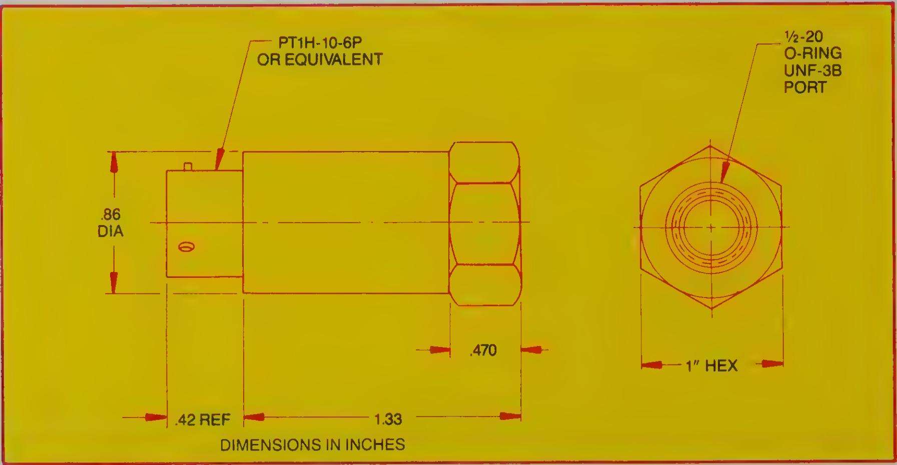
- **Quick Disconnect Feature**
  See Page C-4 for Mating Connectors: PT06F-10-6S
- **Corrosion Resistant 17-4 Stainless Steel**

From
$150



Shown actual size

See Page B-13 For "O" Rings #2-013



To Order *(Specify model number)*

RANGE	MODEL	PRICE
0- 300 PSIG	PX 306-300G V	$175
▶ 0- 500 PSIG	PX 306-500G V	150 ◀
0- 750 PSIG	PX 306-750G V	150
▶ 0-1000 PSIG	PX 306- 1 KG V	150 ◀
0-1500 PSIG	PX 306- 1.5KG V	150
▶ 0-2500 PSIG	PX 306- 2.5KG V	150 ◀
0-3500 PSIG	PX 306- 3.5KG V	150
▶ 0-5000 PSIG	PX 306- 5 KG V	150 ◀
0-7500 PSIG	PX 306- 7.5KG V	150

▶ *HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY* ◀

SPECIFICATIONS

Accuracy: Within ±0.5% full scale output (terminal linearity) including non-linearity, hysteresis, and repeatability
Repeatability: Within 0.05% full scale output
Operating Temperature Range: −100°F to +290°F (−73°C to +143°C)
Compensated Temperature Range: −40°F to +260°F (−40°C to +127°C)
Thermal Effects on Zero: ±0.005% full scale/°F typical (±0.01% full scale/°C)
Thermal Effects on Sensitivity: ±0.003% reading/°F typical (±0.006% reading/°C)

ELECTRICAL CHARACTERISTICS

Full Scale Output at 10 V dc: 30 mV ±0.5% for 500 PSI and above
30 mV ±5.0% for 300 PSI
Excitation: 10 volts recommended, 12 volts maximum
Sensitivity: 3 mV/V ±0.5% for 500 PSI and above,
3 mV/V ±5.0% for 300 PSI
Zero Balance: ±2% full scale
Bridge Resistance: 410 ohms nominal input and 350 ohms nominal output

MECHANICAL CHARACTERISTICS

Safe Overpressure: 1.5 times rated pressure without damage
Burst Pressure: Four times rated pressure minimum
Material: 17-4 PH Stainless Steel
Weight: 3 oz.
Pressure Port: ½-20 UNF with O-ring port (#2-013)

HIGH ACCURACY WITH INTEGRAL SHUNT CALIBRATOR

831 Series
0-5 to 0-5,000 PSIG

- **Quick Disconnect Feature**
  See Page C-4 for Mating Connectors: PT06F-10-6S
- **Rugged Corrosion Resistant Construction**
- **±0.25% Accuracy**

From $555

Shown actual size

The 831 Series transducers incorporate a modular design of standardized components that are welded together to form an assembly that is highly accurate, reliable, and stable. An integral shunt resistor provides 80% of full scale output when external contacts are made and no pressure is applied. This facilitates field calibration of the entire system and not individual components.

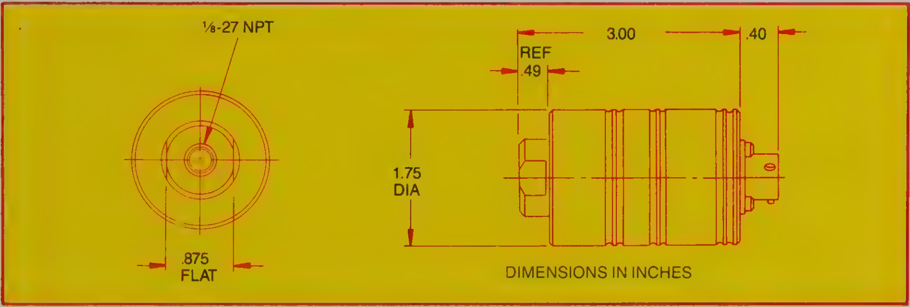
PSIA or PSIS versions available. Add **$50**
Consult Sales Department.

SPECIFICATIONS

Excitation: 10 V dc
Output: 30 mV ±0.25%
Proof Pressure: 150% of rated pressure
Input Impedance: 350 ±5 ohms
Output Impedance: 350 ±5 ohms

PERFORMANCE

Terminal Linearity: ±0.15% full scale
Hysteresis: ±0.10% full scale
Repeatability: ±0.05% full scale
Stability: <0.25% of full scale drift in 6 months
Zero Balance: ±1% full scale
Compensated Temp. Range: 0°F to 150°F
Thermal Zero Effect: ±0.3% FS/100°F
Thermal Span Effect: ±0.3% FS/100°F
Operable Temperature Range: −65° to 250°F



DIMENSIONS IN INCHES

CONSTRUCTION:

Body/Diaphragm Material: 303, 304SS/17-4 PH, 15-5 PH, AM 350
Pressure Port: ⅛-27 NPT, internal

Electrical Connections: PT02A-10-6P 6 pin connector
Diaphragm Protection: Overload stops installed for ranges of 25 PSI and under

To Order *(Specify model number)*

RANGE	MODEL	PRICE
◆ 0- 5 PSIG	PX 831-005G V	$625 ◆
0- 10 PSIG	PX 831-010G V	625
0- 25 PSIG	PX 831-025G V	625
◆ 0- 50 PSIG	PX 831-050G V	555 ◆
◆ 0- 100 PSIG	PX 831-100G V	555 ◆
0- 250 PSIG	PX 831-250G V	555
◆ 0- 500 PSIG	PX 831-500G V	555 ◆
0- 750 PSIG	PX 831-750G V	555
◆ 0-1000 PSIG	PX 831-1KG V	555 ◆
0-5000 PSIG	PX 831-5KG V	555

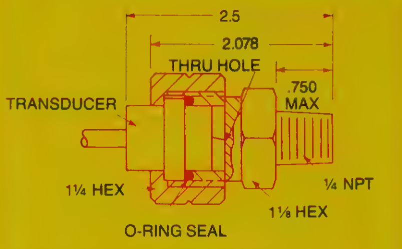
◆ *HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY* ◆

FLUSH MOUNT ADAPTORS
FOR SERIES 102, 440 AND 510 TRANSDUCERS

TO 20,000 PSI

DIMENSIONS IN INCHES

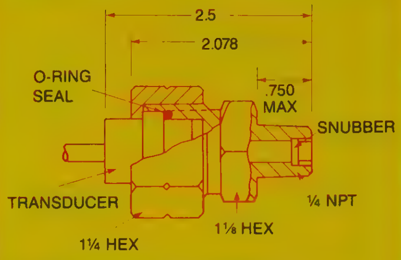
AD-1SS 10,000 psi


2.5
2.078
THRU HOLE
.750
MAX
TRANSDUCER
1¼ HEX
¼ NPT
1⅛ HEX
O-RING SEAL

300 Series Stainless Steel,
¼″ NPT male

$20

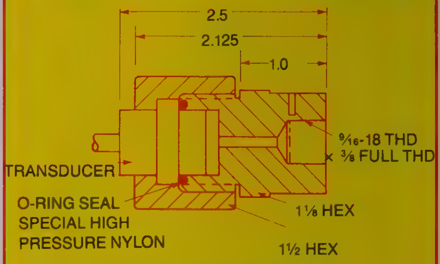
AD-1SF 10,000 psi


2.5
2.078
O-RING
SEAL
.750
MAX
SNUBBER
TRANSDUCER
¼ NPT
1⅛ HEX
1¼ HEX

300 Series Stainless Steel,
¼″ NPT male Snubber,
40 microns adaptor

$30

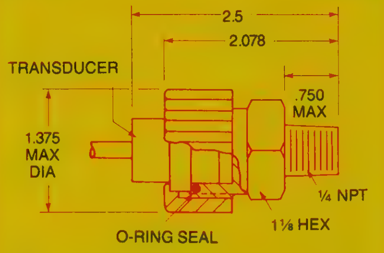
AD-5SS 20,000 psi


2.5
2.125
1.0
⁹⁄₁₆-18 THD
× ⅜ FULL THD
TRANSDUCER
O-RING SEAL
SPECIAL HIGH
PRESSURE NYLON
1⅛ HEX
1½ HEX

416 Stainless Steel high
pressure autoclave fitting,
⁹⁄₁₆″ - 18 thread × ⅜″

$70

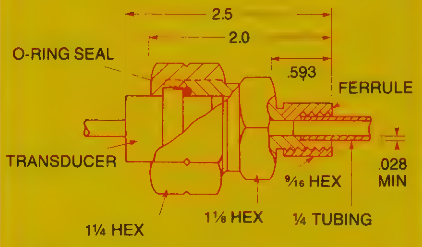
AD-1N 200 psi


2.5
2.078
TRANSDUCER
.750
MAX
1.375
MAX
DIA
¼ NPT
1⅛ HEX
O-RING SEAL

Nylon, ¼″ NPT male

$15

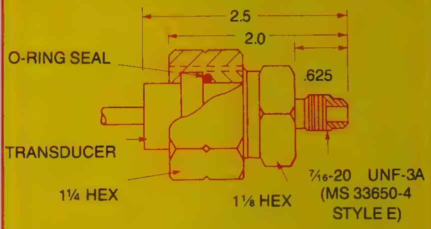
AD-2SS 3,000 psi


2.5
2.0
O-RING SEAL
.593
FERRULE
TRANSDUCER
.028
MIN
⁹⁄₁₆ HEX
1⅛ HEX
¼ TUBING
1¼ HEX

300 Series Stainless Steel,
¼″ tube fitting

$75

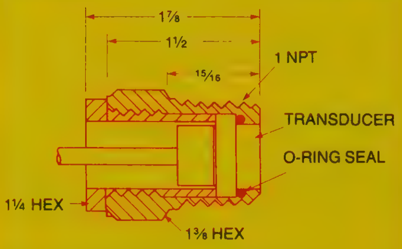
AD-6SS 10,000 psi


2.5
2.0
O-RING SEAL
.625
TRANSDUCER
⁷⁄₁₆-20 UNF-3A
(MS 33650-4
STYLE E)
1¼ HEX
1⅛ HEX

300 Series Stainless Steel,
MS-33656-4 male thread

$60

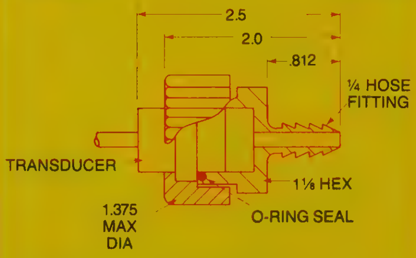
AD-3SS 10,000 psi


1⅞
1½
1 NPT
¹⁵⁄₁₆
TRANSDUCER
O-RING SEAL
1¼ HEX
1⅜ HEX

300 Series Stainless Steel,
1″ NPT male flush mounting

$60

AD-4N 100 psi


2.5
2.0
.812
¼ HOSE
FITTING
TRANSDUCER
1⅛ HEX
1.375
MAX
DIA
O-RING SEAL

Nylon, barbed fitting for
¼″ ID hose

$15

"O" RINGS

Use for pressures under 10,000 psi:

#2-018-V
VITON . . . . **$10/Pk of 10**

#2-013-V
VITON . . . . **$10/Pk of 10**

Use for pressures of 10,000 psi and higher:

#2-018-P
POLYURETHANE . . . **$15/Pk of 10**

#2-013-P
POLYURETHANE . . . **$15/Pk of 10**

FLUSH MOUNT GENERAL PURPOSE MODULE

102 Series

0-6, 15, 25, 50, 100, 200, 500, 1,000, 2,000, 3,000, 5,000, 10,000, 15,000, & 20,000 PSIG

$165

Shown twice actual size

102 Series General Purpose transducers have been developed for those applications where accuracy, repeatability and cost are major considerations.

102 Series transducers feature high signal levels and low output impedances, and are capable of driving many readily available panel meters without amplification. Interfaced with appropriate signal conditioners and controllers, they can be used to activate a wide variety of instruments, readouts, controls or alarms.

SPECIFICATIONS

Excitation: 5 V dc
Output: 100 mV ±1%
Proof Pressure: 2x range (30K psi max)
Input Impedance: 150 ± 50 ohms
Output Impedance: 115 ± 25 ohms

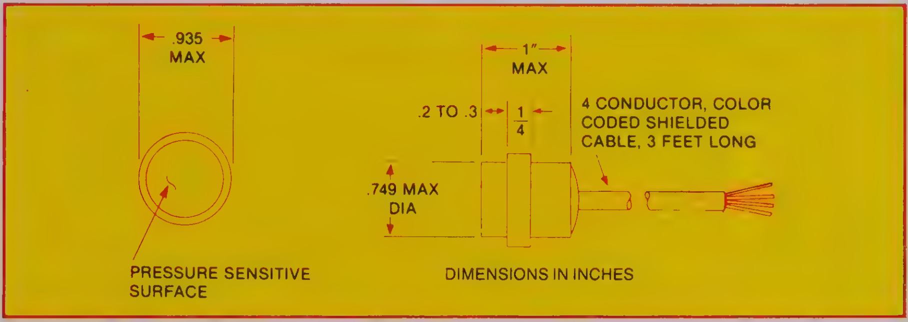
PERFORMANCE

Accuracy: 1% from best fit straight line (includes linearity, hysteresis and repeatability)
Zero Balance: ±5 mV at 70°F
Compensated Temp. Range: 30° to 130°F
Thermal Zero Effect: < 5%
Thermal Span Effect: < 2%
Operable Temperature Range: −65° to 200°F

CONSTRUCTION

Body/Diaphragm Material: 316L SS for 50 psi and under; 15-5 PH SS over 50 psi

▶ *HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY* ◀


.935 MAX
1" MAX
.2 TO .3
1/4
4 CONDUCTOR, COLOR CODED SHIELDED CABLE, 3 FEET LONG
.749 MAX DIA
PRESSURE SENSITIVE SURFACE
DIMENSIONS IN INCHES

To Order *(Specify Model Number)*

RANGE	MODEL	PRICE
0- 5 PSIG	PX 102-006G V	$165
0- 15 PSIG	PX 102-015G V	165
0- 25 PSIG	PX 102-025G V	165
▶ 0- 50 PSIG	PX 102-050G V	165 ◀
▶ 0- 100 PSIG	PX 102-100G V	165 ◀
0- 200 PSIS	PX 102-200G V	165
▶ 0- 500 PSIS	PX 102-500G V	165 ◀
▶ 0- 1000 PSIS	PX 102- 1KG V	165 ◀
0- 2000 PSIS	PX 102- 2KG V	165
0- 3000 PSIS	PX 102- 3KG V	165
▶ 0- 5000 PSIS	PX 102- 5KG V	165 ◀
0-10000 PSIS	PX 102-10KG V	165
0-15000 PSIS	PX 102-15KG V	165
0-20000 PSIS	PX 102-20KG V	165

Units 100 psi and above have cases sealed from the surrounding atmosphere, providing maximum reliability in humid or corrosive environment (psis). Ranges below 100 psi are vented to the atmosphere and read gage pressure.

PRESSURE MEASUREMENT OF DRY GASES *POSITIVE AND BI-POLAR*

140 Series

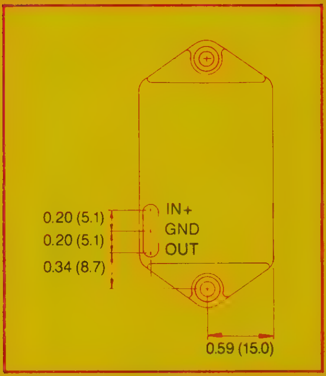
±2.5 PSI to 0-30 PSI

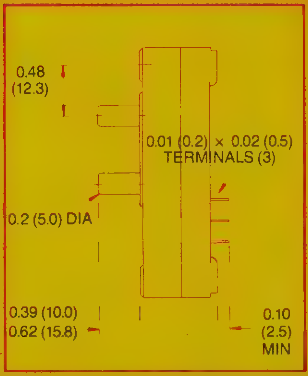
From $68

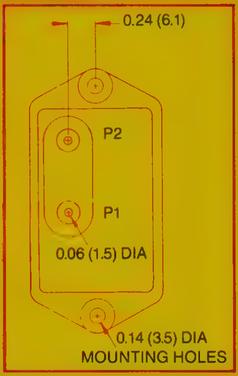
Shown slightly larger than actual size

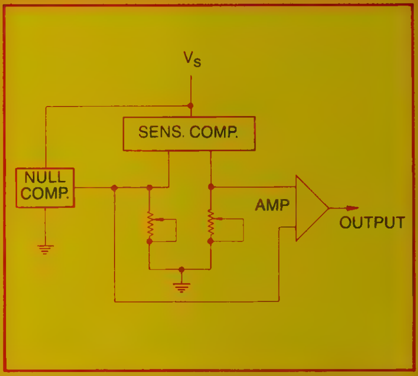
SILICON DIAPHRAGM

- **High level output**
- **1-6 V dc with 8 V dc excitation**
- **Positive pressure measurement, differential gage and absolute types**
- **Positive and negative pressure measurement differential and gage types**
- **Printed circuit board terminals . . . exit on opposite side from the ports**
- **Rugged-Printed Circuit Board Construction**
- **High Impact Plastic Case**
- **Accurate: All Models Temperature Compensated**


IN+
GND
OUT
0.20 (5.1)
0.20 (5.1)
0.34 (8.7)
0.59 (15.0)


0.48 (12.3)
0.01 (0.2) × 0.02 (0.5) TERMINALS (3)
0.2 (5.0) DIA
0.39 (10.0)
0.62 (15.8)
0.10 (2.5) MIN


0.24 (6.1)
P2
P1
0.06 (1.5) DIA
0.14 (3.5) DIA MOUNTING HOLES


Vs
SENS. COMP.
NULL COMP.
AMP
OUTPUT

DIMENSIONS IN INCHES

To Order *(Specify model number)*

RANGE	SENSITIVITY	MODEL	PRICE
0-5 PSID	1.00 V/PSI	PX 142-005D 5V	$68
◆ 0-5 PSIG	1.00 V/PSI	PX 142-005G 5V	68 ◆
0-15 PSID	0.333 V/PSI	PX 142-015D 5V	68
◆ 0-15 PSIG	0.333 V/PSI	PX 142-015G 5V	68 ◆
◆ 0-15 PSIA	0.333 V/PSI	PX 142-015A 5V	75 ◆
0-30 PSID	0.167 V/PSI	PX-142-030D 5V	68
0-30 PSIG	0.167 V/PSI	PX 142-030G 5V	68
0-30 PSIA	0.167 V/PSI	PX 142-030A 5V	75
±2.5 PSID	1.00 V/PSI	PX 143-2.5BD 5V	68
◆ ±5 PSID	0.50 V/PSI	PX 143-05BD 5V	68 ◆
±5 PSIG	0.50 V/PSI	PX 143-05BG 5V	68
◆ ±15 PSID	0.167 V/PSI	PX 143-15BD 5V	68 ◆
±15 PSIG	0.167 V/PSI	PX 143-15BG 5V	68

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

SEE PAGE C-3 FOR CONNECTORS.

140 Series sensors measure positive pressures and are offered for differential gage and absolute measurement. Differential and gage types measure pressure over three ranges (0-5, 0-15, 0-30 psi). Absolute types are available in two ranges (0-15 and 0-30 psi).

140 sensors are also available in differential and gage types to measure positive/negative pressures over ±2.5, ±5 and ±15 psi.

TUBING PAGE C-9

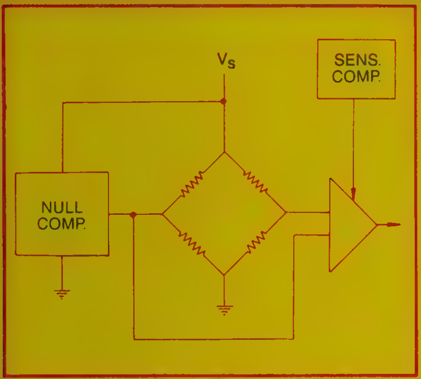
LOW PRESSURE MEASUREMENT
OF DRY GASES

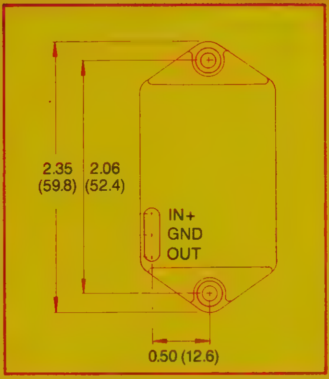
160 Series
0-27.68″ H_20
±5″ H_20
0-10″ H_20

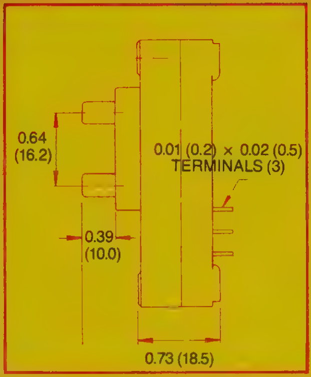
From
$85

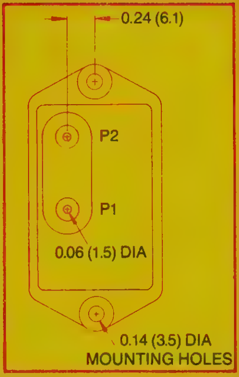
SILICON DIAPHRAGM
- 1 to 6 V Output Span
- Differential
- Gage
- High Level Output
- 8 V dc Excitation
- High Impact Plastic Case
- Temperature Compensated

Shown slightly larger than actual size


Vs
SENS. COMP.
NULL COMP.


2.35 (59.8)
2.06 (52.4)
IN+
GND
OUT
0.50 (12.6)


0.64 (16.2)
0.01 (0.2) × 0.02 (0.5) TERMINALS (3)
0.39 (10.0)
0.73 (18.5)


0.24 (6.1)
P2
P1
0.06 (1.5) DIA
0.14 (3.5) DIA MOUNTING HOLES

DIMENSIONS IN INCHES

160 Series measure pressure in very low ranges such as ±5″ H_2O 0-10″ H_2O and 0-27.68″ H_2O (0-1 psi). The gage and differential type sensors feature excellent sensitivity.

Both 140 and 160 Series are contained in thermoplastic housings. The .010″ × .020″ printed circuit board terminals exit on the opposite side from the ports.

For best linearity, keep P1 > P2. Damage will not occur for overpressures up to 5 psi.

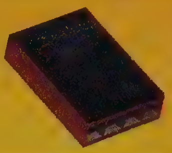
To Order *(Specify model number)*

RANGE	SENSITIVITY	MODEL	PRICE
(Inches H_2O)	(Volt/in H_2O)		
27.68-0 D*	0.18	PX 161-027D 5V	$85
0-27.68 D	0.18	PX 162-027D 5V	85
0-27.68 G	0.18	PX 162-027G 5V	85
±5 D	0.50	PX 163-005BD 5V	100
0-10 D	0.50	PX 164-010D 5V	100

**Zero output at 27.68″ H_2O*

HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY

Connectors are Available on Page C-3.



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RUGGED SIGNAL CONDITIONER
WITH HIGH ACCURACY FOR GENERAL PURPOSE USE
STAINLESS STEEL PRESSURE CHAMBER

176 Series
0-15 to 0-5000 PSI

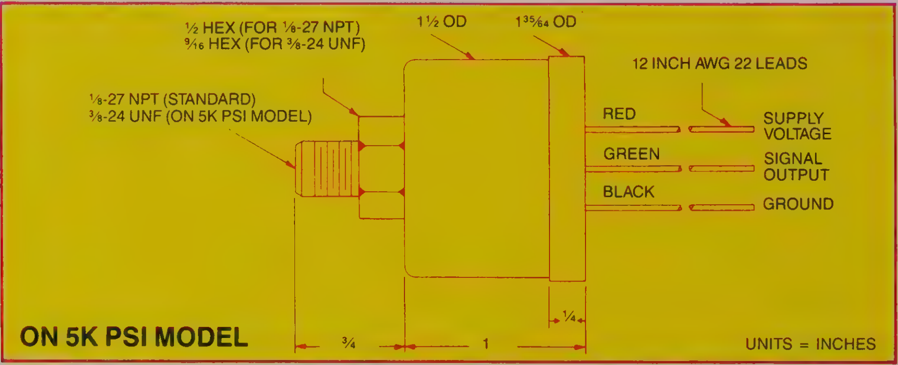
- ±1% Interchangeability
- Sealed for Harsh Environments
- 1 to 6 V dc Output
- 9 to 20 V dc Power Source
- −55 to 125°C Operating Range
- Fully Calibrated and Temperature Compensated

Supplied with 12" Shielded Leads

$215

Shown slightly larger than actual size

SEE PAGE C-13 FOR REDUCING BUSHINGS TO FIT YOUR SYSTEM



To Order *(Specify model number)*

RANGE	MODEL	PRICE
0- 15 PSIA	PX 176-015A 5V	$215
◆ 0- 25 PSIA	PX 176-025A 5V	215 ◆
0- 50 PSIA	PX 176-050A 5V	215
0- 100 PSIS*	PX 176-100S 5V	215
◆ 0- 200 PSIS*	PX 176-200S 5V	215 ◆
◆ 0- 500 PSIS*	PX 176-500S 5V	215 ◆
0-1000 PSIS*	PX 176-1KS 5V	215
0-5000 PSIS*	PX 176-5KS 5V	215

**Measured with respect to a standard atmosphere (14.7 PSIA)*

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

The 176 Series PSIS/PSIA pressure transducer is a high gain strain gage device with a hybrid amplifier providing a conditioned output. The 5 volt output is capable of directly driving control, indicator, or alarm circuitry without external amplification. It is designed to meet the needs of today's high technology requirements. The 176 Series is the ideal choice for those applications that need a sealed transducer that is rugged, reliable, and cost-efficient with the benefits of 0.5% accuracy, long-term stability and a wide operating temperature range.

A unique stainless steel pressure chamber design insures circuit protection from corrosive measurand while the rugged sealed case protects against harsh environments. This combination assures long-term performance within original specification limits. The internal voltage regulator allows use of economical unregulated power sources from 9-20 V dc.

Typical media used with the 176 Series include oil, gases, saline solutions, hydraulic fluids, alcohol, ammonia, acids, and gasoline.

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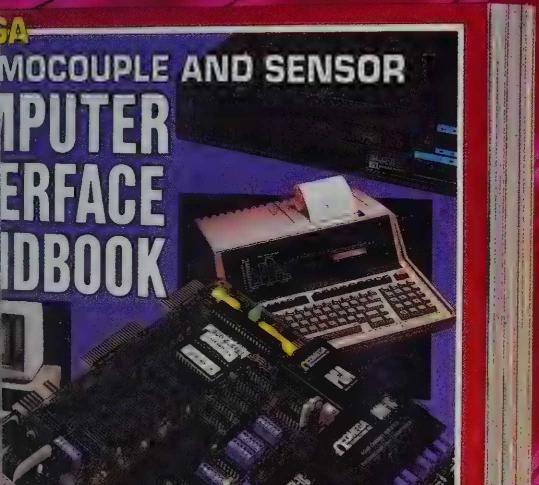
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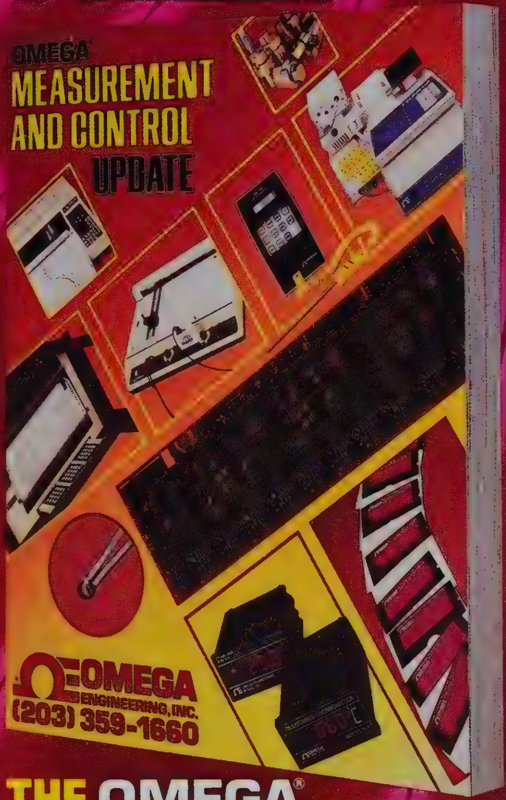
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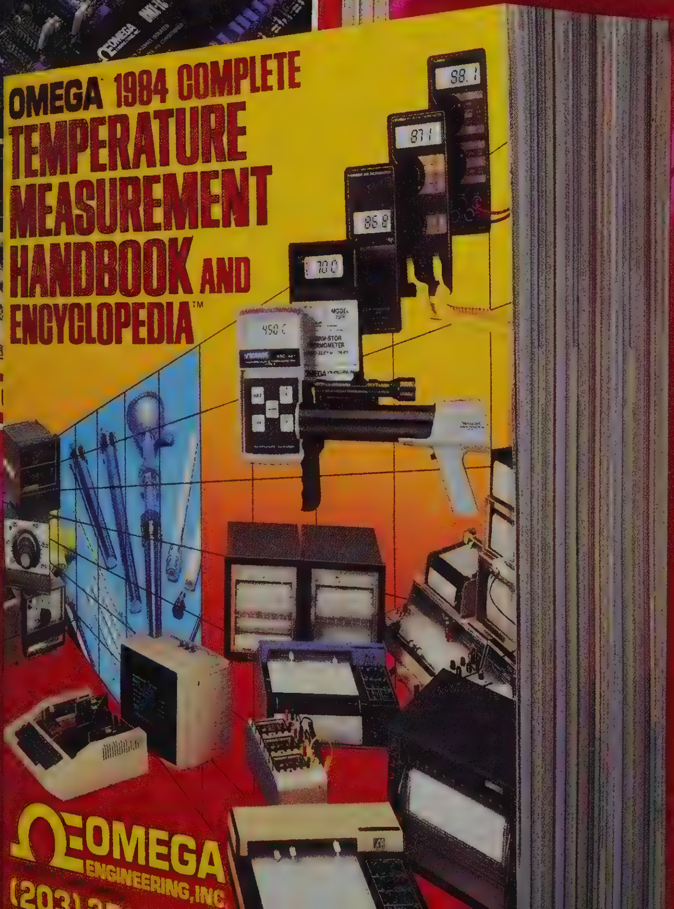
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GAGE TYPE PRESSURE TRANSDUCERS
FOR NON-CAUSTIC LIQUIDS & GASES

OMEGA
ENGINEERING, INC.

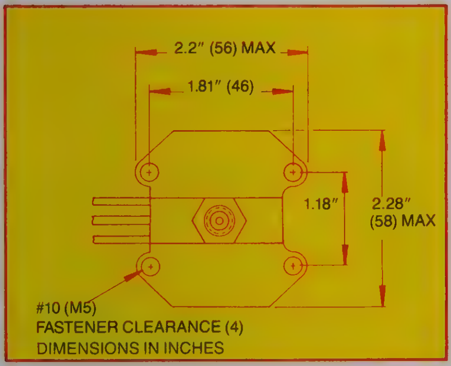
240 Series
5-250 PSIG FULL SCALE

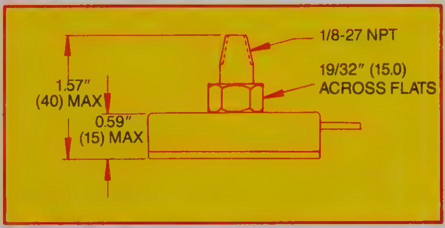
$100

SILICON DIAPHRAGM
- Buna-N Seals
- 8.0 V dc Excitation
- 12 Inch Leadwires
- −40 to +85°C
- 1 to 6 V dc Output
- Temperature Compensated
- Rugged Low Profile Easy-to-Mount

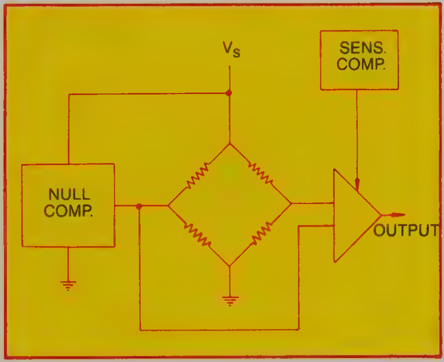
Supplied with 12″ Leads

Shown 1½ times larger than actual size


2.2″ (56) MAX
1.81″ (46)
1.18″
2.28″ (58) MAX
#10 (M5) FASTENER CLEARANCE (4)
DIMENSIONS IN INCHES


1/8-27 NPT
19/32″ (15.0) ACROSS FLATS
1.57″ (40) MAX
0.59″ (15) MAX

Transducer Schematic


V_S
SENS. COMP.
NULL COMP.
OUTPUT

The 240PC Series is available in gage type to measure pressures ranging from ±2.5 psi to 0-250 psi. The sensor is protected by a die-cast aluminum housing which is epoxy painted to resist corrosion. Media compatibility for oils, fuels, gasoline, petroleum based lubricants, hydraulic fluids, alcohol, water and air is provided by internal Buna-N O-ring seals. Termination is by 300 mm (12 in.) long, color coded 18 gage leadwires.

COMPLETE YOUR SYSTEM.
SEE SECTION D FOR INSTRUMENTATION.

To Order *(Specify model number)*

RANGE	SENSITIVITY	MODEL	PRICE
−5 to 0 PSIG	1.0 V/PSIG	PX 241-05NG 5V	$100
−15 to 0 PSIG	0.330 V/PSIG	PX 241-15NG 5V	100
0 to 5 PSIG	1.00 V/PSIG	PX 242-005G 5V	100
0 to 15 PSIG	0.330 V/PSIG	PX 242-015G 5V	100
◆ 0 to 30 PSIG	0.167 V/PSIG	PX 242-030G 5V	100 ◆
0 to 60 PSIG	0.083 V/PSIG	PX 242-060G 5V	100
◆ 0 to 100 PSIG	0.050 V/PSIG	PX 242-100G 5V	100 ◆
0 to 150 PSIG	0.033 V/PSIG	PX 242-150G 5V	100
◆ 0 to 250 PSIG	0.020 V/PSIG	PX 242-250G 5V	100 ◆
±2.5 PSIG	1.0 V/PSIG	PX 243-2.5BG 5V	100
±5.0 PSIG	0.5 V/PSIG	PX 243-05BG 5V	100
◆ ±15 PSIG	0.167 V/PSIG	PX 243-15BG 5V	100 ◆

◆ *HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY* ◆

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240 Series
5-250 PSIG FULL SCALE

$100

SILICON DIAPHRAGM
- Buna-N Seals
- 8.0 V dc Excitation
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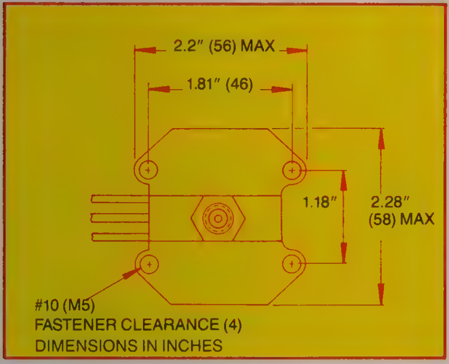
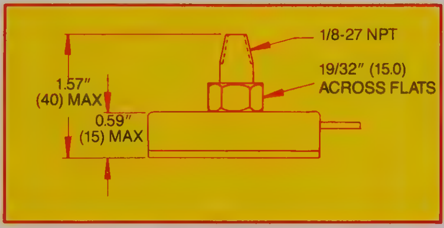
- −40 to +85°C
- 1 to 6 V dc Output
- Temperature Compensated
- Rugged Low Profile Easy-to-Mount

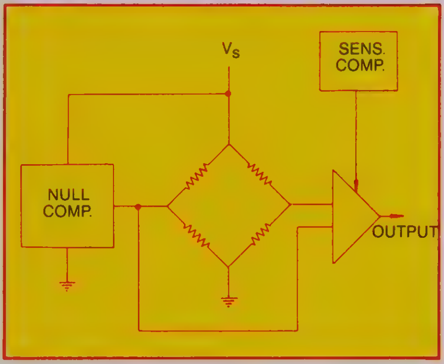
Supplied with 12″ Leads

Shown 1½ times larger than actual size


2.2″ (56) MAX
1.81″ (46)
1.18″
2.28″ (58) MAX
#10 (M5) FASTENER CLEARANCE (4)
DIMENSIONS IN INCHES


1/8-27 NPT
19/32″ (15.0) ACROSS FLATS
1.57″ (40) MAX
0.59″ (15) MAX

Transducer Schematic


Vs
SENS. COMP.
NULL COMP.
OUTPUT

The 240PC Series is available in gage type to measure pressures ranging from ±2.5 psi to 0-250 psi. The sensor is protected by a die-cast aluminum housing which is epoxy painted to resist corrosion. Media compatibility for oils, fuels, gasoline, petroleum based lubricants, hydraulic fluids, alcohol, water and air is provided by internal Buna-N O-ring seals. Termination is by 300 mm (12 in.) long, color coded 18 gage leadwires.

COMPLETE YOUR SYSTEM. SEE SECTION D FOR INSTRUMENTATION.

To Order *(Specify model number)*

RANGE	SENSITIVITY	MODEL	PRICE
−5 to 0 PSIG	1.0 V/PSIG	PX 241-05NG 5V	$100
−15 to 0 PSIG	0.330 V/PSIG	PX 241-15NG 5V	100
0 to 5 PSIG	1.00 V/PSIG	PX 242-005G 5V	100
0 to 15 PSIG	0.330 V/PSIG	PX 242-015G 5V	100
◆ 0 to 30 PSIG	0.167 V/PSIG	PX 242-030G 5V	100 ◆
0 to 60 PSIG	0.083 V/PSIG	PX 242-060G 5V	100
◆ 0 to 100 PSIG	0.050 V/PSIG	PX 242-100G 5V	100 ◆
0 to 150 PSIG	0.033 V/PSIG	PX 242-150G 5V	100
◆ 0 to 250 PSIG	0.020 V/PSIG	PX 242-250G 5V	100 ◆
±2.5 PSIG	1.0 V/PSIG	PX 243-2.5BG 5V	100
±5.0 PSIG	0.5 V/PSIG	PX 243-05BG 5V	100
◆ ±15 PSIG	0.167 V/PSIG	PX 243-15BG 5V	100 ◆

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

HIGH LEVEL OUTPUT
5 VOLT & 10 VOLT GENERAL PURPOSE TRANSDUCER

303 Series
0-50 to 0-10,000

$205

Shown actual size

SPECIFICATIONS

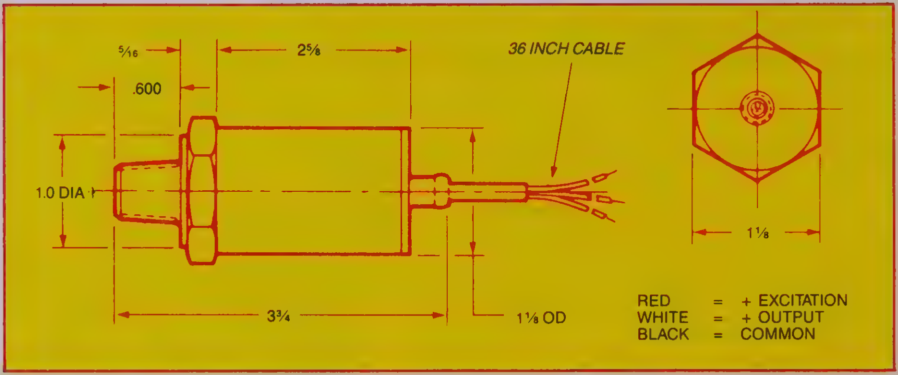
Excitation: 14-32 V dc
Output: 0.5-5.5 V dc or 1-11 V dc
Proof Pressure: 2x full scale or 15,000 psi (whichever is less)
Maximum Quiescent Excitation Current: 16 mA
Minimum Output Load Resistance: 2K ohm
Reverse Supply Voltage: Reverse Polarity will not damage unit.

PERFORMANCE

Accuracy: ±0.5% of full scale at 75°F (linearity, hysteresis, and repeatability)
Zero Balance: ±2% of full scale at +75°F
Output Tolerance (Sensitivity): ±1% of full scale at +75°F
Compensated Temp. Range: +30° to +130°F standard
Thermal Zero Effect: ±.02%/deg. F (over compensated temperature range)
Thermal Span Effect: ±.02%/deg. F (over compensated temperature range)
Operable Temperature Range: 0 to 160°F

CONSTRUCTION

Body Diaphragm Material: 17-4 ph stainless steel
Pressure Port: ¼-18 NPT standard
Pressure Cavity Volume: .065 cubic inches maximum



RED = + EXCITATION
WHITE = + OUTPUT
BLACK = COMMON

Teflon Tape
page C-12

To Order *(Specify model number)*

RANGE PSIG	MODEL NUMBER FOR 5 VOLT OUTPUT	PRICE	MODEL NUMBER FOR 10 VOLT OUTPUT	PRICE
0- 50	PX 303-050G 5V	$205	PX 303-050G 10V	$205
◆ 0- 100	PX 303-100G 5V	205	PX 303-100G 10V	205 ◆
◆ 0- 300	PX 303-300G 5V	205	PX 303-300G 10V	205 ◆
◆ 0- 500	PX 303-500G 5V	205	PX 303-500G 10V	205 ◆
0- 750	PX 303-750G 5V	205	PX-303-750G 10V	205
◆ 0- 1000	PX 303- 1 KG 5V	205	PX 303- 1 KG 10V	205 ◆
0- 2000	PX 303- 2 KG 5V	205	PX 303- 2 KG 10V	205
0- 4000	PX 303- 4 KG 5V	205	PX 303- 4 KG 10V	205
◆ 0- 5000	PX 303- 5 KG 5V	205	PX 303- 5 KG 10V	205 ◆
0- 7500	PX 303- 7.5KG 5V	205	PX 303- 7.5KG 10V	205
0-10000	PX 303-10 KG 5V	205	PX 303-10 KG 10V	205

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

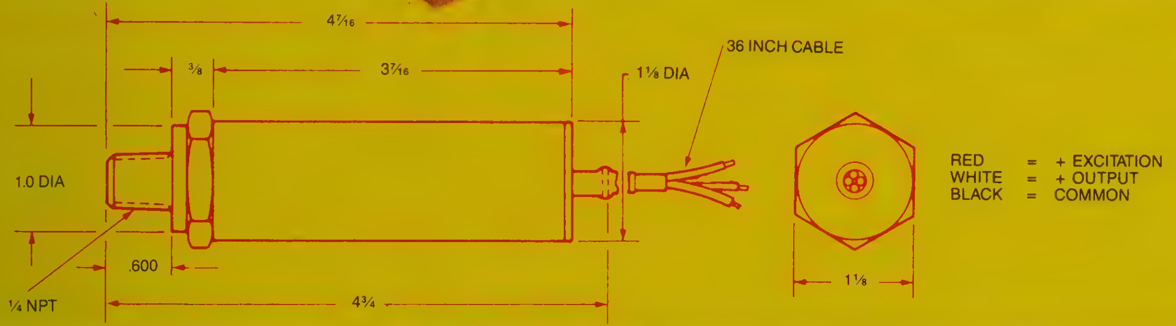
304 Series

0-50, 0-100, 0-150, 0-300 PSIA

- **Wide Operating Temperature Range**
- **Absolute Readings Not Affected by Ambient Pressure**
- **Rugged 17-4 Stainless Steel**

$240

Not shown actual size



SPECIFICATIONS

Excitation: 12-32 V dc
Output: 0.5-5.5 V dc
Proof Pressure: 2x full scale
Maximum Quiescent Excitation Current: 16 mA
Minimum Output Load Resistance: 2K ohm
Reverse Supply Voltage: Reverse Polarity will not damage unit.

PERFORMANCE

Accuracy: ±0.5% full scale at 75°F (linearity, hysteresis, and repetability)
Zero Balance: ±2% of full scale at +75°F
Output Tolerance (Sensitivity): ±1% of full scale at +75°F
Compensated Temp. Range: +30° to +130°F standard
Thermal Zero Effect: ±.02%/deg. F (over compensated temperature range)
Thermal Span Effect: ±.02%/deg. F (over compensated temperature range)
Operable Temperature Range: 0 to 160°F

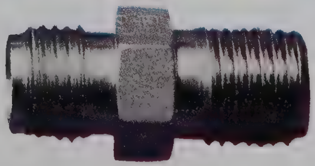
CONSTRUCTION

Body Diaphragm Material: 17-4 PH stainless steel construction
Pressure Port: ¼-18 NPT standard
Pressure Cavity Volume: .0687 cubic inches maximum

To Order *(Specify model number)*

RANGE	MODEL	PRICE
◆ 0- 50 PSIA	PX 304-050A 5V	$240 ◆
0-100 PSIA	PX 304-100A 5V	240
◆ 0-150 PSIA	PX 304-150A 5V	240 ◆
0-300 PSIA	PX 304-300A 5V	240

◆ *HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY* ◆



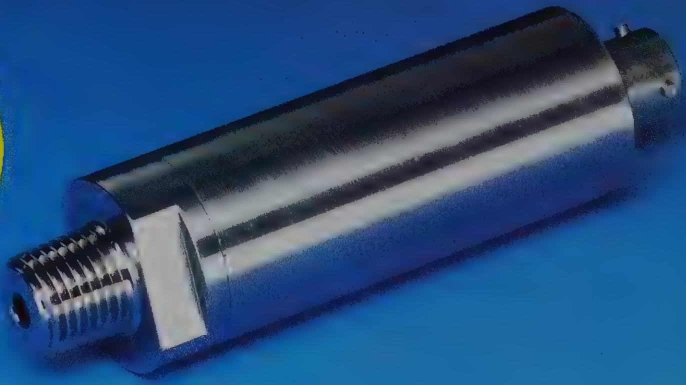
Fittings Bushings
page C-13

THREAD MOUNT GENERAL PURPOSE

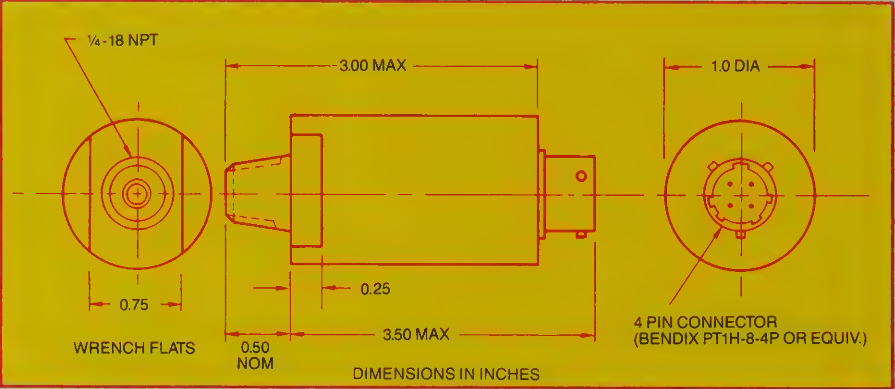
500 Series
0-15 to 0-5000 PSIG

- High Level Output
- Quick Disconnect Feature
  See Page C-4 for Mating Connectors: PT06F-8-4S

$305



Shown actual size



To Order *(Specify model number)*

RANGE	MODEL	PRICE
◆ 0- 15 PSIG	PX 500-015G 5V	$305 ◆
0- 30 PSIG	PX 500-030G 5V	305
◆ 0- 50 PSIG	PX 500-050G 5V	305 ◆
◆ 0- 100 PSIG	PX 500-100G 5V	305 ◆
0- 200 PSIG	PX 500-200G 5V	305
◆ 0- 500 PSIG	PX 500-500G 5V	305 ◆
0-1000 PSIG	PX 500-1KG 5V	305
0-2000 PSIG	PX 500-2KG 5V	305
0-5000 PSIG	PX 500-5KG 5V	305

Absolute Ranges Available: Add $10

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

The weld-sealed pressure cavity is entirely of 17-4PH stainless steel, making the PX 500 ideal for use with most corrosive fluids. The strain-gage signal is amplified to a high-level output by an integral solid-state signal conditioning module.

The PX 500 is available in ranges from 0-15 to 0-5000 psi for gage or absolute pressure measurements. The PSIG (gage) version references to the atmosphere; the PSIA (absolute) version references to an internal vacuum.

SPECIFICATIONS

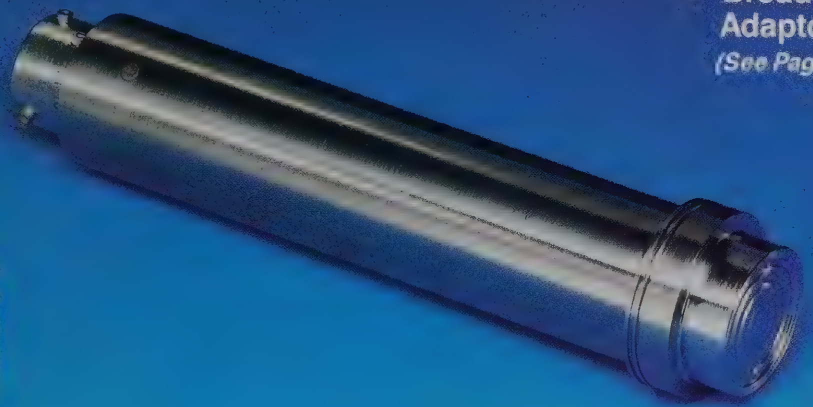
Excitation: 24-32 V dc
Output: 0-5 V dc FS
Accuracy (Comb. L.H.R.): ±0.5% FS
Resolution: Infinite
Zero Balance: ±1.0% FS
Output Impedance: 50 ohms max
Input/Output Isolation: Common input/output return
Current Drain: 15 mA nominal
Connector: Bendix PTIH-8-4P or equal
Materials: 17-4PH
Pressure Fitting: ¼-18 NPT
Pressure Cavity Volume: 0.1 cubic inch nominal
Temperature
  Operating Range: −65 to +255°F
  Compensated Range: 0 to +130°F
Thermal Effect on Zero: ±.01% FS/°F
Thermal Effect on Sensitivity: ±.01% FS/°F

FLUSH MOUNT GENERAL PURPOSE

510 Series

0-5 to 0-10,000 PSIG

- Stainless Steel Construction for Corrosion Resistance
- Quick Disconnect Feature
  See Page C-4 for Mating Connectors: PT06F-10-6S
- Broad Line of Mounting Adaptors
  (See Page B-13)



$375

Shown actual size

SPECIFICATIONS

Excitation: 12-20 V dc
Output: 0-5 V dc
Proof Pressure: 2x scale

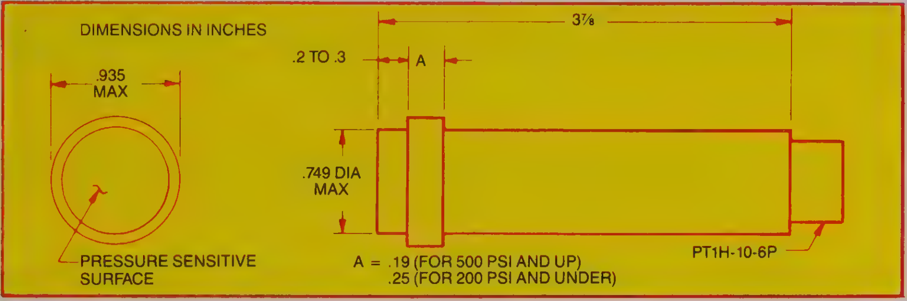
PERFORMANCE

Accuracy: ±1% full scale at 75°F (linearity, hysteresis, and repeatability)
Zero Balance: ±2% of full scale at +75°F

CONSTRUCTION

Body/Diaphragm Material: 316L Stainless Steel ranges 50 psi and under. 15-5 PH Stainless Steel ranges 100 psi and over.

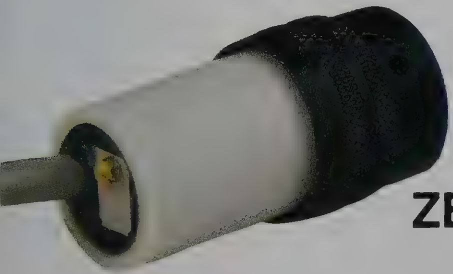
The ZB-510 accessory is a mating electrical connector for the Model 510 transducer including a manually adjustable zero balance circuit. The ZB-510 connector may be installed on the 510 transducer and then used to adjust the signal output to 0 V dc at 0 inlet pressure. The ZB-510 accessory eliminates he need for signal conditioning equipment in many applications.


DIMENSIONS IN INCHES
.935 MAX
PRESSURE SENSITIVE SURFACE
3⅞
.2 TO .3
A
.749 DIA MAX
A = .19 (FOR 500 PSI AND UP)
.25 (FOR 200 PSI AND UNDER)
PT1H-10-6P

To Order *(Specify model number)*

RANGE	MODEL	PRICE
◆ 0- 5 PSIG	PX 510-005G 5V	$375 ◆
0- 15 PSIG	PX 510-015G 5V	375
0- 25 PSIG	PX 510-025G 5V	375
◆ 0- 50 PSIG	PX 510-050G 5V	375 ◆
◆ 0- 100 PSIS	PX 510-100G 5V	375 ◆
0- 200 PSIS	PX 510-200G 5V	375
◆ 0- 500 PSIS	PX 510-500G 5V	375 ◆
0- 1000 PSIS	PX 510- 1KG 5V	375
0- 2000 PSIS	PX 510- 2KG 5V	375
0- 3000 PSIS	PX 510- 3KG 5V	375
0- 5000 PSIS	PX 510- 5KG 5V	375
0-10000 PSIS	PX 510-10KG 5V	375

◆HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY◆



ZB-510 $50

See Mounting Hardware on page B-13

HIGH ACCURACY WITH INTEGRAL SHUNT CALIBRATOR

851 Series

0-5 to 0-5,000 PSI

From $465

See Page C-4 for Mating Connectors: PT06F 10-6S

- ±0.25% Accuracy
- Quick Disconnect Feature
- Rugged Weather Tight Construction

Shown ¾ actual size

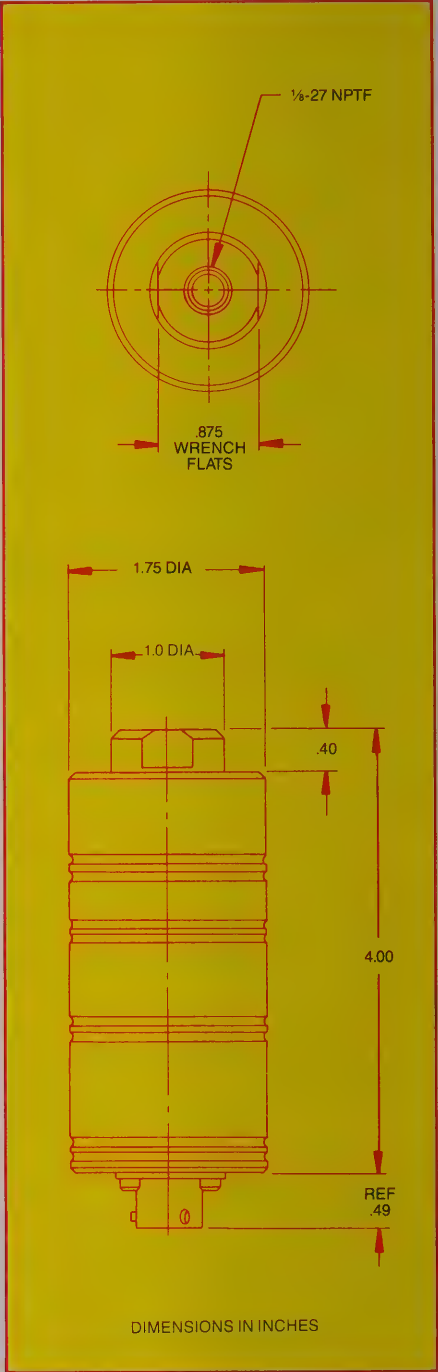
To Order *(Specify model number)*

RANGE	MODEL	PRICE
0- 5 PSIG	PX 851-005G 5V	$795
◆ 0- 10 PSIG	PX 851-010G 5V	795 ◆
0- 15 PSIG	PX 851-015G 5V	795
0- 20 PSIG	PX 851-020G 5V	795
◆ 0- 25 PSIG	PX 851-025G 5V	795 ◆
0- 50 PSIG	PX 851-050G 5V	780
0- 100 PSIG	PX 851-100G 5V	780
0- 200 PSIG	PX 851-200G 5V	780
◆ 0- 250 PSIG	PX 851-250G 5V	780 ◆
0- 350 PSIG	PX 851-350G 5V	780
◆ 0- 500 PSIG	PX 851-500G 5V	780 ◆
0- 750 PSIG	PX 851-750G 5V	780
◆ 0-1000 PSIG	PX 851-1 KG 5V	465 ◆
0-1500 PSIG	PX 851-1.5KG 5V	465
0-2000 PSIG	PX 851-2 KG 5V	465
◆ 0-2500 PSIG	PX 851-2.5KG 5V	465 ◆
0-3000 PSIG	PX 851-3 KG 5V	465
0-5000 PSIG	PX 851-5 KG 5V	465

PSIA and PSIS Models also available on request. Change the G in the model number and add $50 to the base price.

Note: *Models up through 750 psi include overload stops for transducer protection.*

◆ **HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY** ◆



SPECIFICATIONS

Excitation: 24 to 32 V dc (or ±12 to ±16 V dc)
Output: 5 V dc
Zero and Span Adjustment: ±5%
Shunt Calibration: 80% full span
Accuracy: ±0.3% full scale at 75°F (linearity, hysteresis, and repeatability)
Wetted Material: 17-4 PH, 15-5 PH or AM350 Stainless Steel
Cover Material: 303, 304 stainless steel
Connector: PT02A-10-6P

COMPACT 316SS TRANSDUCER
FEMALE INPUT PORT

110 Series
0-15 to 0-3,000 PSIG/A

- Integral Voltage Transmitter
- High Level 5 V Output

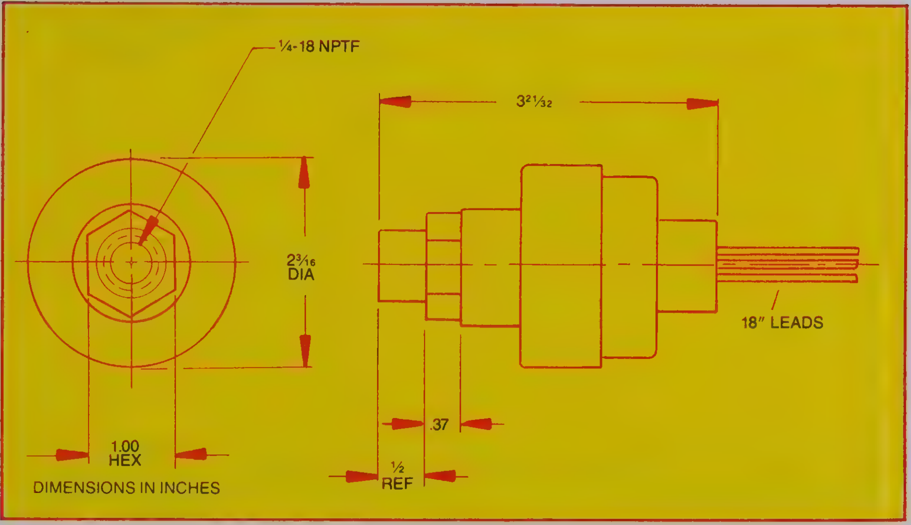
$295

Corrosion Resistant
Epoxy/Aluminum Housing

Shown actual size

SPECIFICATIONS

Excitation: 12.5 to 36 V dc
Output: .5 to 5.5 V dc
Proof Pressure: 1.5 × maximum span
Accuracy: ±0.5% full scale at 75°F (linearity, hysteresis, and repeatability)
Compensated Temperature Range: −30 to +80°C standard
Body Diaphragm Material: 316 SS
Pressure Port: ¼-18 NPTF
Electrical Connections: 18″ pigtails
Fill Fluid: Dimethylsiloxane (DC-200)
Body: Epoxy painted aluminum alloy



COMPLETE YOUR SYSTEM. SEE SECTION C FOR POWER SUPPLIES.

To Order *(Specify model number)*

	GAGE RANGE	PRICE	ABSOLUTE RANGE	PRICE
0- 15 PSI	PX 110-015G V	$295	PX 110-015A V	$295
▶ 0- 30 PSI	PX 110-030G V	295 ◀	PX 110-030A V	295
0- 50 PSI	PX 110-050G V	295	PX 110-050A V	295
▶ 0- 100 PSI	PX 110-100G V	295 ◀	PX 110-100A V	295
0- 300 PSI	PX 110-300G V	295	PX 110-300A V	295
0- 500 PSI	PX 110-500G V	295	PX 110-500A V	295
▶ 0-1000 PSI	PX 110-1KG V	295 ◀	PX 110-1KA V	295
▶ 0-3000 PSI	PX 110-3KG V	295 ◀	PX 110-3KA V	295

▶ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◀

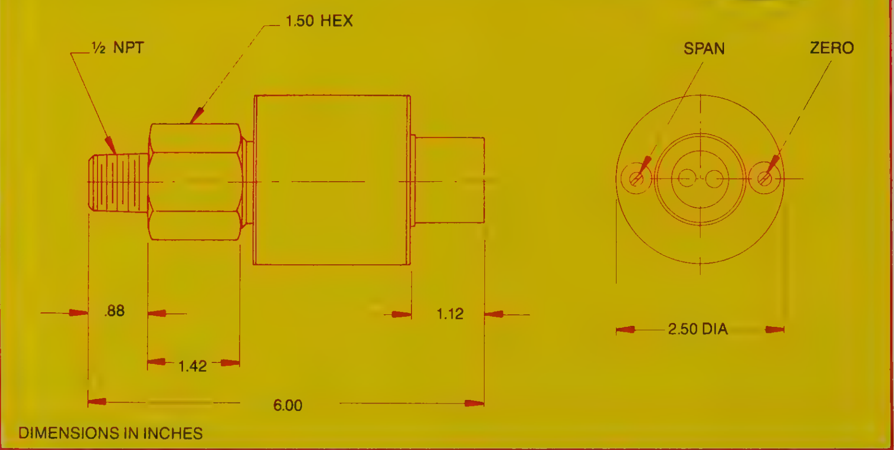
½ NPT PROCESS CONNECTION
.5 to 5.5 Volt

027 Series
0-30 to 0-3,000 PSIG

- ½% Accuracy (Including Linearity, Repeatability and Hysteresis)
- .5 to 5.5 Volt Output
- 12.5 to 36 V dc Excitation
- 316SS Cavity and Shell
- External Zero and Span Adjustments with O-Ring Seals
- −40° to 120°C Media Temperature
- −30° to +80°C Ambient Temperature
- Weathertight Construction
- Dimethylsiloxane Fill Fluid

$450

Shown actual size


1.50 HEX
½ NPT
SPAN
ZERO
.88
1.12
2.50 DIA
1.42
6.00

DIMENSIONS IN INCHES

The Model PX 027 was designed for industrial applications where shock, vibration, RFI and weather conditions must be tolerated. These features make the Model PX 027 an ideal selection for process control applications in chemical, petroleum, and water management environments.

To Order *(Specify model number)*

RANGE	MODEL	PRICE
0- 30 PSIG	PX 027-030G 5V	$450
◆ 0- 100 PSIG	PX 027-100G 5V	450 ◆
0- 300 PSIG	PX 027-300G 5V	450
◆ 0-1000 PSIG	PX 027-1KG 5V	450 ◆
0-3000 PSIG	PX 027-3KG 5V	450

Absolute pressure ranges available on special order.

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

MODEL R15P250
SERIAL NO PS 1283
CALIBRATION 5V @ 500 mA
AMPS
VOLTAGE 110
OMEGA
ENGINEERING, INC.
Stamford, CT 06907

SEE POWER SUPPLIES C-7, 8

EM RUGGED STYLE TRANSDUCER

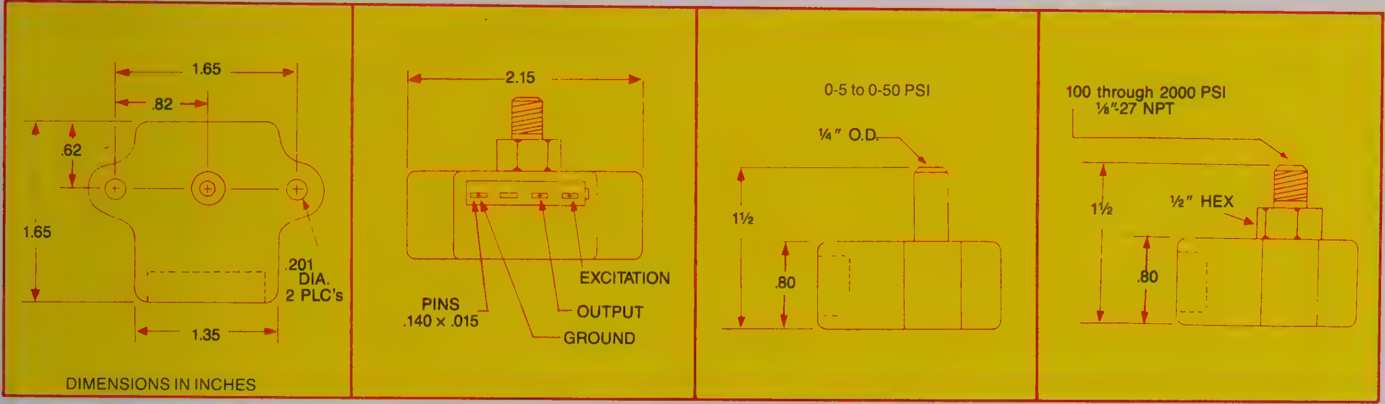
105 Series
0-5 to 0-2,000 PSIG

$180

- Voltage output 1 to 6 V dc
- 8-20 V dc Excitation
- Accuracy: ±0.5% Typ
- Fully Calibrated and Temperature Compensated
- Internal Voltage Regulation
- Interchangeable: Unit to Unit ±1%
- Computer Trimmed to Insure Accuracy and Repeatability
- Long-Term Stability: ±1%
- Operating Temperature Range: −55°C to 125°C
- Rugged Temperature-Resistant Valox Case and Connector

Shown actual size

Connector included



The PX 105 Pressure Transducer is a high gain strain gage device with a hybrid amplifier providing a conditioned output. The 5 volt output is capable of driving control, indicator, or alarm circuitry directly without external amplification.

The PX 105 is the ideal choice for those applications that need a rugged, reliable, cost efficient transducer with the benefits of 0.5% accuracy, long-term stability and a wide operating temperature range.

A unique stainless steel pressure chamber design insures circuit protection from corrosive measurand while the outer case of Valox protects against harsh environments.

To Order *(Specify model number)*

RANGE	MODEL	PRICE
0- 5 PSIG	PX 105-006G 5V	$180
◆ 0- 15 PSIG	PX 105-015G 5V	180 ◆
0- 25 PSIG	PX 105-025G 5V	180
◆ 0- 50 PSIG	PX 105-050G 5V	180 ◆
◆ 0- 100 PSIG	PX 105-100G 5V	180 ◆
0- 200 PSIG	PX 105-200G 5V	180
◆ 0- 500 PSIG	PX 105-500G 5V	180 ◆
0-1000 PSIG	PX 105-1KG 5V	180
0-2000 PSIG	PX 105-2KG 5V	180

◆ **HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY** ◆

1-6 KHz OUTPUT

FREQUENCY MODULATED SQUARE WAVE OUTPUT WITH QUICK CONNECT PLUG

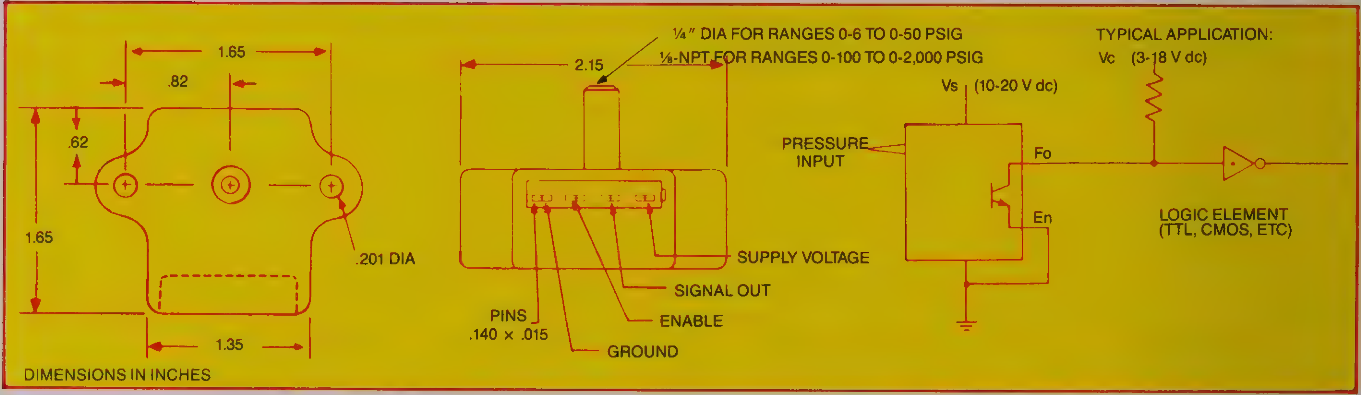
106 Series

0-5 to 0-2,000 PSIG

- **10-20 V dc Excitation**
- **0.5% Accuracy**
- **−40° to +85°C Operation**
- **Valox Outer Case**
- **Stainless Steel Chamber**
- **±1% FS Stability**

$215

Connector included


1.65
.82
.62
1.65
.201 DIA
1.35
DIMENSIONS IN INCHES
2.15
¼" DIA FOR RANGES 0-6 TO 0-50 PSIG
⅛-NPT FOR RANGES 0-100 TO 0-2,000 PSIG
PINS
.140 × .015
SUPPLY VOLTAGE
SIGNAL OUT
ENABLE
GROUND
TYPICAL APPLICATION:
Vc (3-18 V dc)
Vs (10-20 V dc)
PRESSURE INPUT
Fo
En
LOGIC ELEMENT
(TTL, CMOS, ETC)

To Order *(Specify model number)*

PRESSURE RANGE	MODEL NUMBER	PRICE
0- 5 PSIG	PX 106-006G 5F	$215
0- 15 PSIG	PX 106-015G 5F	215
0- 25 PSIG	PX 106-025G 5F	215
▶ 0- 50 PSIG	PX 106-050G 5F	215 ◀
▶ 0- 100 PSIG	PX 106-100G 5F	215 ◀
0- 200 PSIG	PX 106-200G 5F	215
0- 300 PSIG	PX 106-300G 5F	215
▶ 0- 500 PSIG	PX 106-500G 5F	215 ◀
0-1000 PSIG	PX 106-1KG 5F	215
0-2000 PSIG	PX 106-2KG 5F	215

▶ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◀

TYPICAL APPLICATION:

Unique stainless steel pressure chamber design insures circuit protection from corrosive measurand while the outer case of Valox protects against harsh environments. This combination assures the 106 Series performance to continue within original specification limits.

No maintenance is required with these transducers. The absence of moving parts and the solid-state electronics make them trouble-free and reliable.

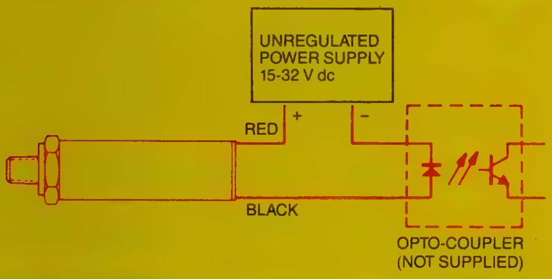
1-11 KHz OUTPUT
WIDE PRESSURE RANGE FREQUENCY MODULATED CURRENT LOOP

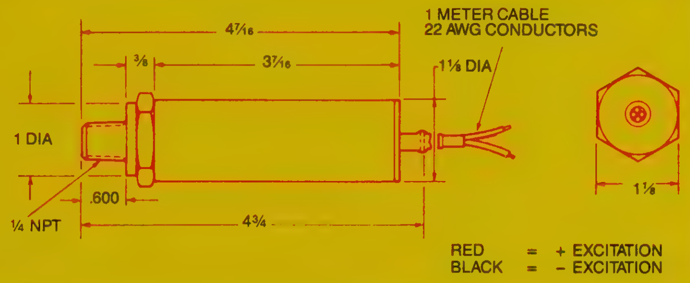
11 Series
-50 to 0-10,000 PSIG

- 15-32 V dc Excitation
- 0.5% Accuracy
- +30° to +130°F Compensated Range
- 17-4 PH Stainless Steel Diaphragm
- High Noise Immunity

$240

Not shown actual size


UNREGULATED
POWER SUPPLY
15-32 V dc
+
–
RED
BLACK
OPTO-COUPLER
(NOT SUPPLIED)


4⁷⁄₁₆
⅜
3⁷⁄₁₆
1 METER CABLE
22 AWG CONDUCTORS
1⅛ DIA
1 DIA
.600
¼ NPT
4¾
1⅛
RED = + EXCITATION
BLACK = – EXCITATION

DIMENSIONS IN INCHES

he 311 Series logic level equency output signal offers nique advantages over onventional analog voltage output ansducers. The primary advantage the ease with which the ansducer can be interfaced to nost microprocessors. Another dvantage is superior noise nmunity which allows the sensor to erform in a variety of harsh nvironments without shielded able or special care to protect ansmission lines. Also, since it is a gic level signal at relatively low equency, long communication nes can be used, and simple wave hape reconstruction can be erformed if required.

To Order *(Specify model number)*

PRESSURE RANGE	MODEL NUMBER	PRICE
0- 50 PSIG	PX 311-050G 10F	$240
◆ 0- 100 PSIG	PX 311-100G 10F	240 ◆
0- 300 PSIG	PX 311-300G 10F	240
◆ 0- 500 PSIG	PX 311-500G 10F	240 ◆
0- 750 PSIG	PX 311-750G 10F	240
◆ 0- 1000 PSIG	PX 311- 1KG 10F	240 ◆
0- 2000 PSIG	PX 311- 2KG 10F	240
0- 4000 PSIG	PX 311- 4KG 10F	240
◆ 0- 5000 PSIG	PX 311- 5KG 10F	240 ◆
0- 7500 PSIG	PX 311-7.5KG 10F	240
0-10000 PSIG	PX 311- 10KG 10F	240

◆ HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY ◆

PC MOUNT PNEUMATIC TO CURRENT LOOP CONVERTER

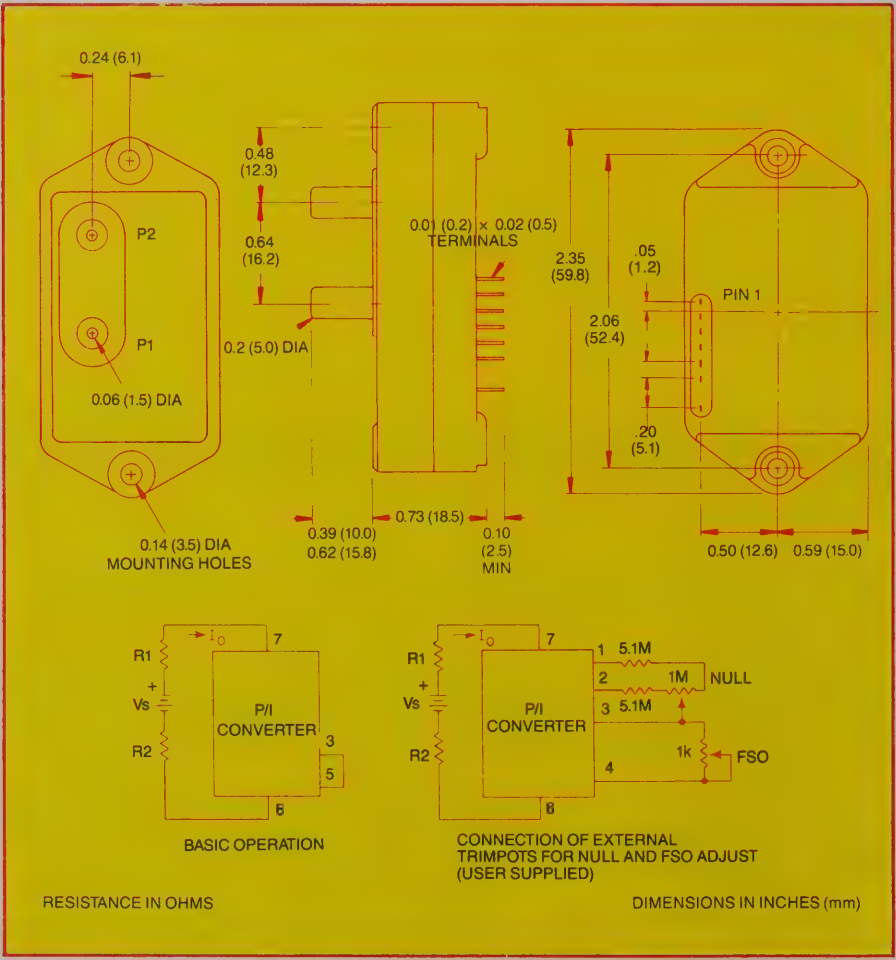
149 Series
3-15 PSID

$95

Model PX149-015D

- Unidirectional Differential Pressure Measurement
- 2-wire, 4-20 mA Current Linearity Proportional to Pressure
- Terminal Pins Provided for Optional External Null and F.S.O. Adjustment
- 10-40 V dc Input Voltage
- Industry Standard Pressure and Current Range
- Silicon Diaphragm

Shown larger than actual size


0.24 (6.1)
P2
P1
0.06 (1.5) DIA
0.14 (3.5) DIA
MOUNTING HOLES
0.48
(12.3)
0.64
(16.2)
0.2 (5.0) DIA
0.01 (0.2) × 0.02 (0.5)
TERMINALS
0.39 (10.0)
0.62 (15.8)
0.73 (18.5)
0.10
(2.5)
MIN
2.35
(59.8)
2.06
(52.4)
.05
(1.2)
PIN 1
.20
(5.1)
0.50 (12.6)
0.59 (15.0)
R1
I_0
7
+
Vs
P/I
CONVERTER
R2
3
5
6
BASIC OPERATION
R1
I_0
7
+
Vs
P/I
CONVERTER
R2
1
5.1M
2
1M
NULL
3
5.1M
1k
FSO
4
8
CONNECTION OF EXTERNAL
TRIMPOTS FOR NULL AND FSO ADJUST
(USER SUPPLIED)
RESISTANCE IN OHMS
DIMENSIONS IN INCHES (mm)

TUBING PAGE C-9

For many applications, a current rather than voltage output is desirable. The current output is less susceptible to errors from electromagnetic interference (EMI), and remains constant over long control lines, eliminating voltage drop problems. The 149 Series pressure-to-current sensor provides this current output. The Pressure transducers placed in series with a 10-40 V dc voltage source, and provides an industry standard 4-20 mA output proportional to pressure over the standard 3-15 PSI pressure range. The compact 149 Series serves the same purpose as larger, more expensive industrial pressure transmitters.

To Order:
Specify PX-149-015D

GENERAL PURPOSE PRESSURE TO 4-20 mA CONVERTER

305 Series
0-50 to 0-10,000 PSIG

- **Precision 4-20 mA Converter**
- **17-4 PH Stainless Steel**
- **Low Cavity Volume**

$225

Not shown actual size

Supplied with 39" (1M) 22 Gage Leads

SPECIFICATIONS

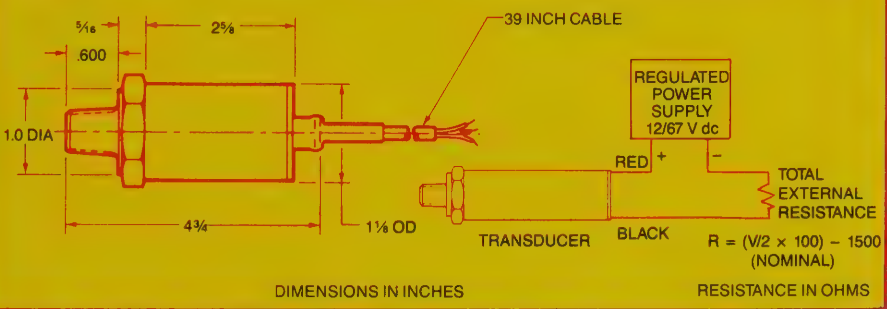
Excitation: 12 V to 67 V dc (with appropriate series resistance)
Output: 4-20 mA
Proof Pressure: 2x full scale or 15,000 PSI (whichever is less)
Minimum Output Load Resistance: (See chart)

PERFORMANCE

Accuracy: ±0.5% full scale at 75°F (linearity, hysteresis, and repeatability)
Zero Balance: ±2.0% of full scale at 75°F
Span Tolerance: ±1.0% of full scale at 75°F
Compensated Temp. Range: +30° to +130°F standard
Thermal Zero Effect: ±.02%/°F (over compensated temperature range)
Thermal Span Effect: ±.02%/°F (over compensated temperature range)
Operable Temperature Range: 0°F to 160°F
Resolution: Infinite
Pressure Range: 0 to 10,000 PSIG

CONSTRUCTION:

Body Diaphragm Material: 17-4 PH stainless steel
Pressure Port: ¼-18 NPT standard
Electrical Connections: See installation outline
Pressure Cavity Volume: .065 cubic inches maximum


5/16
2 5/8
.600
39 INCH CABLE
1.0 DIA
REGULATED POWER SUPPLY 12/67 V dc
RED
+
−
TOTAL EXTERNAL RESISTANCE
4 3/4
1 1/8 OD
TRANSDUCER
BLACK
R = (V/2 x 100) − 1500 (NOMINAL)
DIMENSIONS IN INCHES
RESISTANCE IN OHMS

To Order *(Specify model number)*

RANGE	MODEL	PRICE
0- 50 PSIG	PX 305-050G I	$225
◆ 0- 100 PSIG	PX 305-100G I	225 ◆
0- 300 PSIG	PX 305-300G I	225
◆ 0- 500 PSIG	PX 305-500G I	225 ◆
0- 750 PSIG	PX 305-750G I	225
◆ 0- 1000 PSIG	PX 305- 1 KG I	225 ◆
0- 2000 PSIG	PX 305- 2 KG I	225
0- 4000 PSIG	PX 305- 4 KG I	225
◆ 0- 5000 PSIG	PX 305- 5 KG I	225 ◆
0- 7500 PSIG	PX 305- 7.5KG I	225
0-10000 PSIG	PX 305-10 KG I	225

◆ HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY ◆

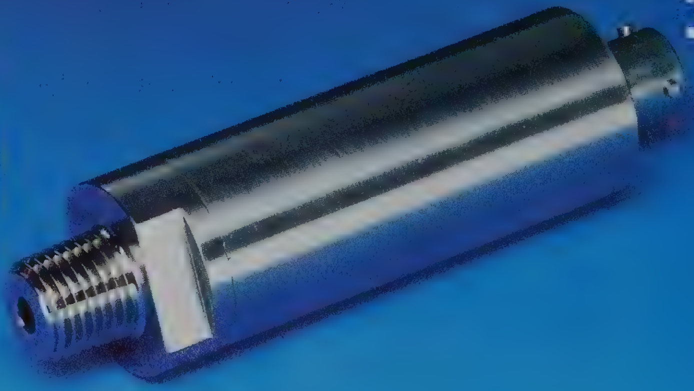
THREAD MOUNT PRESSURE 2-WIRE TRANSMITTER

420 Series

0-15 TO 0-5,000 PSIG
4-20 mA OUTPUT

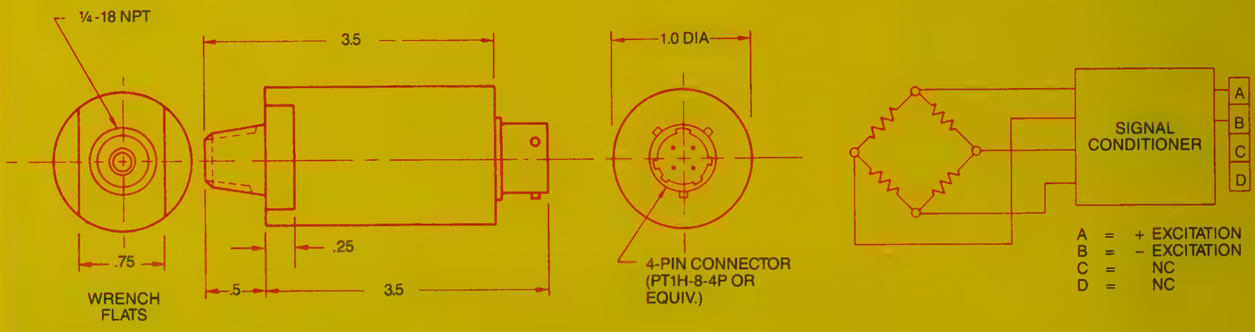
- 24-32 V dc Excitation
- −65 to +255°F Operating Range
- Quick Disconnect
- 200% Overpressure
- 0 to 130°F Compensated Range

$365



Shown actual size

See Page C-4 for Mating Connectors: PT06F-8-4S


¼-18 NPT
3.5
1.0 DIA
SIGNAL CONDITIONER
A
B
C
D
.75
WRENCH FLATS
.25
.5
3.5
4-PIN CONNECTOR (PT1H-8-4P OR EQUIV.)
A = + EXCITATION
B = − EXCITATION
C = NC
D = NC

REDUCING BUSHINGS AVAILABLE—SEE PAGE C-13.

DIMENSIONS IN INCHES

To Order *(Specify model number)*

RANGE	MODEL	PRICE
0- 15 PSIG	PX 420-150G I	**$365**
◆ 0- 50 PSIG	PX 420-050G I	**365** ◆
◆ 0- 100 PSIG	PX 420-100G I	**365** ◆
0- 500 PSIG	PX 420-500G I	**365**
◆ 0-1000 PSIG	PX 420-1KG I	**365** ◆
0-2000 PSIG	PX 420-2KG I	**365**
0-5000 PSIG	PX 420-5KG I	**365**

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

The 420 Series is a rugged, two-wire, 4-20 mA pressure transmitter which operates from supply voltages of 24 to 32 V dc. It utilizes a strain gage bridge bonded to a pressure sensing flat diaphragm. The weld-sealed pressure cavity is entirely of 17-4PH stainless steel, making the unit ideal for use with a wide variety of corrosive fluids.

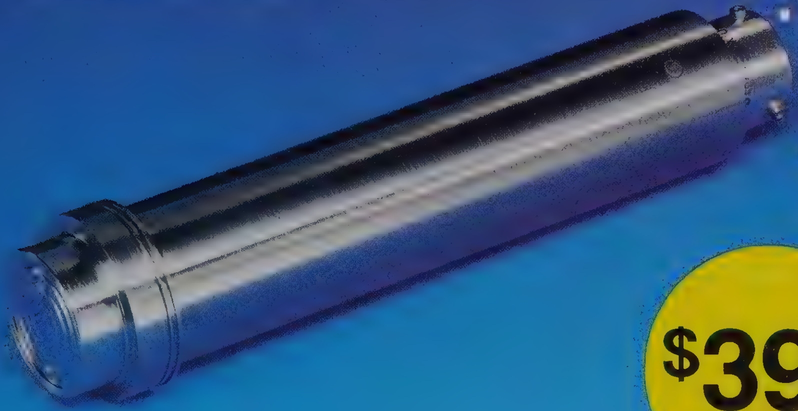
The strain gage signal is amplified and converted to a current output by an integral solid state signal conditioning module inside the stainless steel case.

FLUSH MOUNT WIDE RANGE PRESSURE CONDITIONER

440 Series

0-5 to 0-20,000 PSIG
INTERNAL VOLTAGE REGULATOR

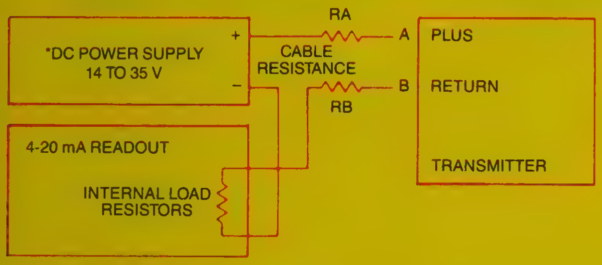
- Unregulated 14 to 50 V dc Excitation
- 316 SS on Ranges 50 psi and under
- 15-5 PH Stainless Steel on 100 and over PSI Ranges
- Ranges 100 PSI and over Are Sealed (PSIS)
- 2,000 Ohms Maximum



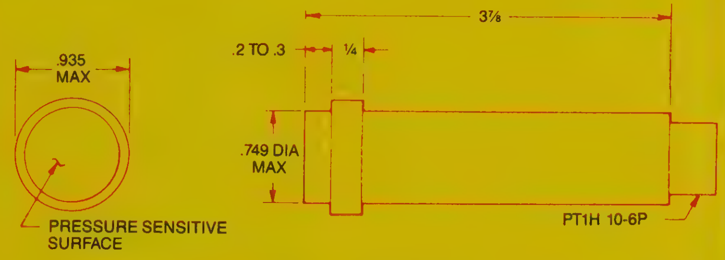
$395

Shown actual size

See Page C-4 for Mating Connectors: PT06F 10-6S


RA
CABLE RESISTANCE
RB
A
B
*DC POWER SUPPLY 14 TO 35 V
+
−
4-20 mA READOUT
INTERNAL LOAD RESISTORS
PLUS
RETURN
TRANSMITTER

***SEE PAGE C-7 FOR POWER SUPPLIES**


.935 MAX
PRESSURE SENSITIVE SURFACE
3⅞
.2 TO .3
¼
.749 DIA MAX
PT1H 10-6P

DIMENSIONS IN INCHES

The 440 Series two-wire Pressure Transmitter is a precision component which receives excitation voltage and transmits a current output over the same pair of wires. Signal transmission accuracy is independent of cable resistance or variations in excitation supply voltage. Internal electronics perform the functions of regulating excitation voltage and convert pressure changes into a variable current output.

Regulated voltage to the bridge and amplifier circuit allows the transmitter to operate from an unregulated dc source of 14 to 50 volts (35 V dc at 200°F). Internal signal conditioning is factory set.

See page B-13 for Mounting Adaptors

To Order *(Specify model number)*

PRESSURE RANGE	MODEL NUMBER	PRICE
0- 5 PSIG	PX 440-005G I	$395
0- 15 PSIG	PX 440-015G I	395
0- 25 PSIG	PX 440-025G I	395
◆ 0- 50 PSIG	PX 440-050G I	395 ◆
◆ 0- 100 PSIG	PX 440-100G I	395 ◆
0- 200 PSIG	PX 440-200G I	395
◆ 0- 500 PSIG	PX 440-500G I	395 ◆
◆ 0- 1000 PSIG	PX 440- 1KG I	395 ◆
0- 5000 PSIG	PX 440- 5KG I	395
0-10000 PSIG	PX 440-10KG I	395
0-20000 PSIG	PX 440-20KG I	395

◆ *HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY* ◆

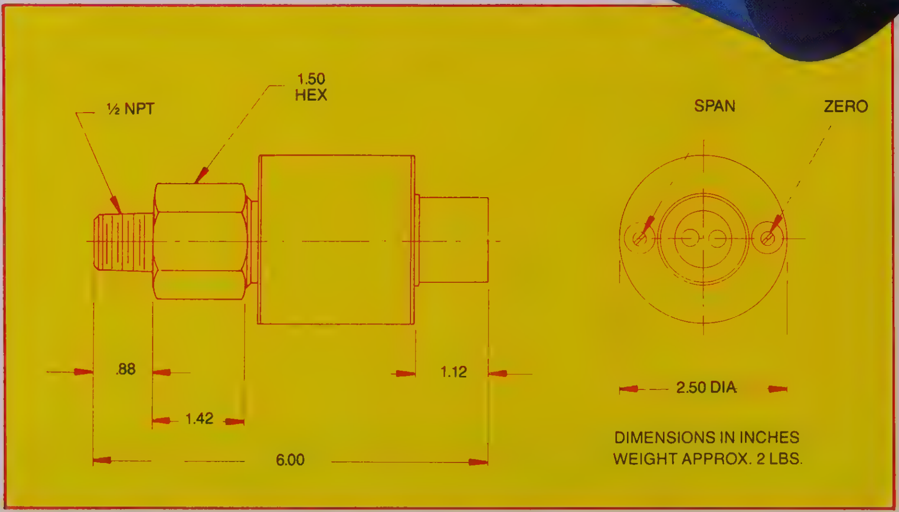
ALL 316SS CONSTRUCTION ½" NPT PROCESS CONNECTION 4-20 mA

027 Series

0-30 TO 0-3,000 PSI

- Rugged Construction for the Process Industry
- Integral Precision 4-20 mA Transmitter
- Zero and Span Adjustments

Shown actual size
18" Leads Supplied



DIMENSIONS IN INCHES
WEIGHT APPROX. 2 LBS.

SPECIFICATIONS

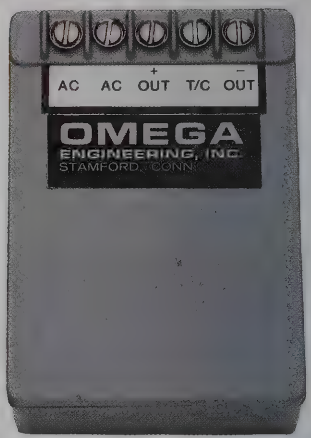
Null Output: 4 mA
Span Output: 16 mA
Static Accuracy: 0.5% of span
Noise: 10 mV Peak to Peak
Zero and Span: Adjustable to 0.05% of span
Repeatability: 0.1% of span
Thermal Accuracy: ±1% span maximum within compensated temperature range, 30°F to 130°F
Life: 10 million cycles
Long Term Stability: Less than 1% drift per year
Excitation: 12-30 V dc

To Order *(Specify model number)*

RANGE	MODEL	PRICE
◆ 0- 30 PSIG	PX 027-030G I	$450 ◆
◆ 0- 100 PSIG	PX 027-100G I	450 ◆
0- 300 PSIG	PX 027-300G I	450
◆ 0-1000 PSIG	PX 027-1KG I	450 ◆
0-3000 PSIG	PX 027-3KG I	450

Absolute pressure ranges available on special order.

◆ *HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY* ◆



POWER SUPPLIES—SEE PAGE C-7, 8

316SS CHAMBER
FEMALE PROCESS CONNECTION 4-20 mA

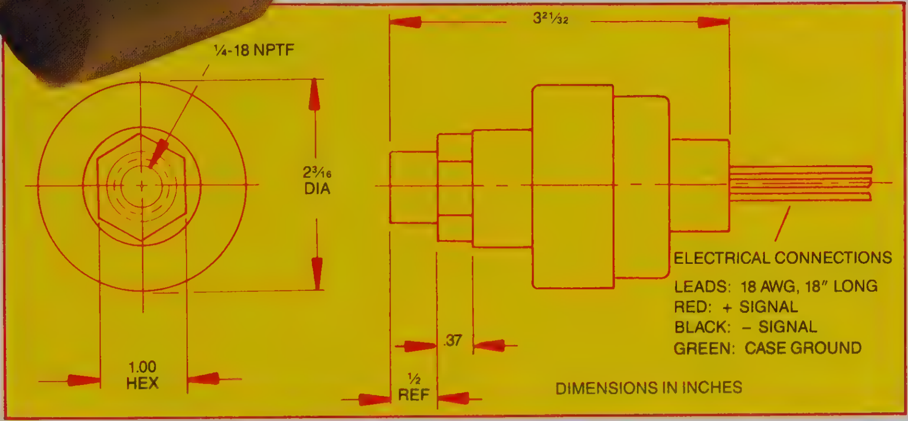
110 Series
0-15 TO 0-3,000 PSI

- **¼-18 Process Thread**
- **Corrosion Resistant Aluminum Housing**
- **Integral 4-20 mA Transmitter**

$295

18" Leads Supplied

Shown actual size


3²¹⁄₃₂
¼-18 NPTF
2³⁄₁₆ DIA
1.00 HEX
.37
½ REF
ELECTRICAL CONNECTIONS
LEADS: 18 AWG, 18" LONG
RED: + SIGNAL
BLACK: – SIGNAL
GREEN: CASE GROUND
DIMENSIONS IN INCHES

SPECIFICATIONS

ELECTRICAL [@ 77°F (25°C) unless otherwise stated]

Excitation: 12 V dc to 30 V dc (unregulated)
Output Signal: 4 to 20 mA dc
Current Output Zero Pressure: 4 mA ±1% mA
Current Output Span: 16 mA ±1% mA
Insulation Resistance: 100 megohms at 50 V dc
Noise: 10 mV peak to peak typical
Static Accuracy (linearity, hysteresis, and repeatability: ±0.5% of span maximum
Thermal Accuracy: ±1.0% of span maximum within compensated temperature range, 30°F (–1°C) to 130°F (54°C).

MECHANICAL

Weight: 6 ounces (170 grams)
Case Material: Cast aluminum housing
Maximum Pressure: 2x rated range, 6,000 PSIG maximum
Medium Compatibility: 316 SS wetted parts

To Order *(Specify model number)*

RANGE	MODEL	PRICE
0- 15 PSIG	PX 110-015G I	$295
◆ 0- 30 PSIG	PX 110-030G I	295 ◆
0- 50 PSIG	PX 110-050G I	295
◆ 0- 100 PSIG	PX 110-100G I	295 ◆
0- 300 PSIG	PX 110-300G I	295
0- 500 PSIG	PX 110-500G I	295
◆ 0-1000 PSIG	PX 110-1KG I	295 ◆
◆ 0-3000 PSIG	PX 110-3KG I	295 ◆

Absolute pressure ranges available on special order.

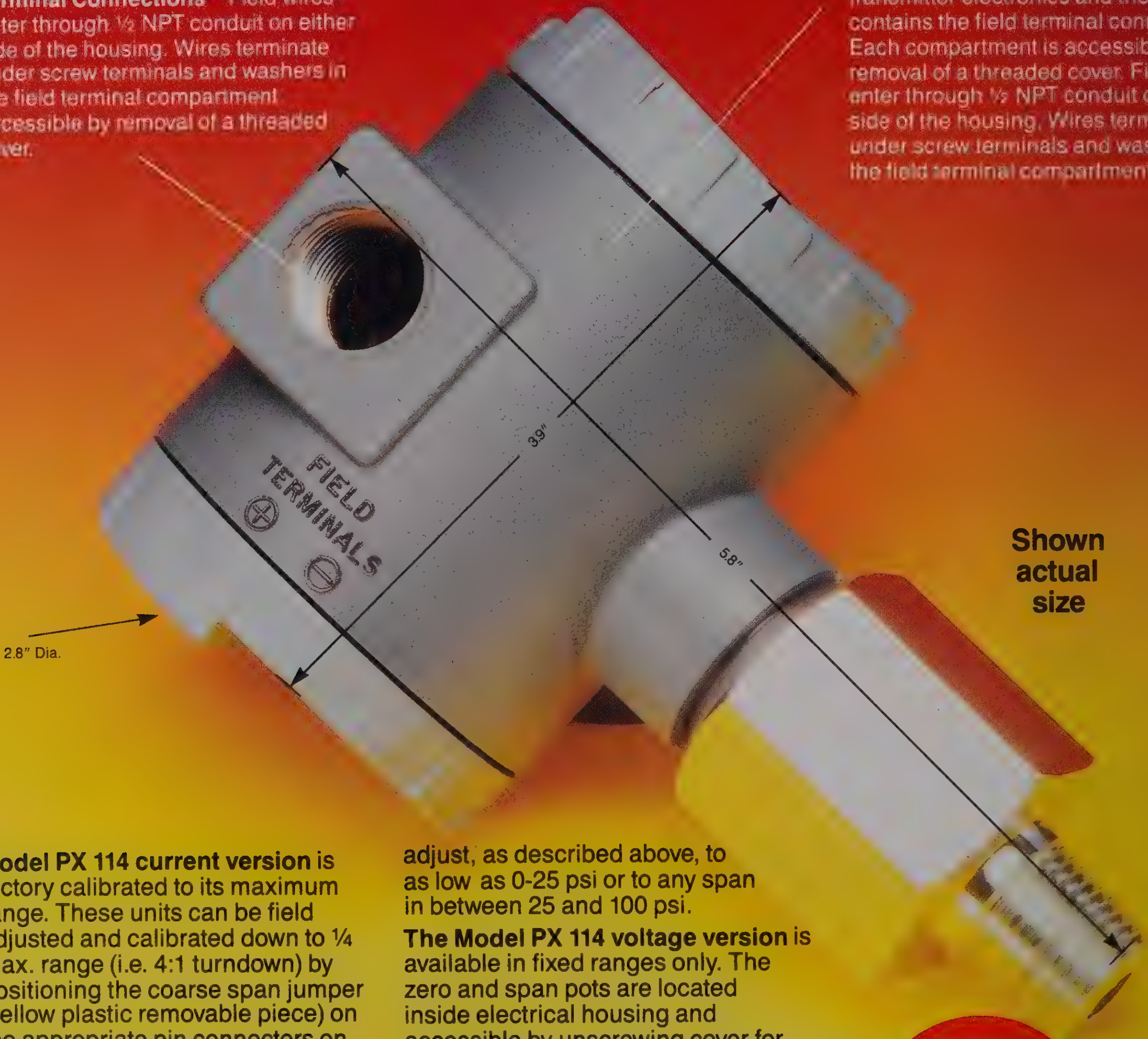
◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

INDUSTRIAL TRANSMITTER VOLTAGE OUTPUT

114 Series

0-7.5 TO 0-3,000 PSI

Rugged Industrial Design



Terminal Connections Field wires enter through ½ NPT conduit on either side of the housing. Wires terminate under screw terminals and washers in the field terminal compartment accessible by removal of a threaded cover.

Housing The transmitter housing is comprised of two separate compartments. One contains the transmitter electronics and the other contains the field terminal connections. Each compartment is accessible by removal of a threaded cover. Field wires enter through ½ NPT conduit on either side of the housing. Wires terminate under screw terminals and washers in the field terminal compartment.

Shown actual size

Model PX 114 current version is factory calibrated to its maximum range. These units can be field adjusted and calibrated down to ¼ max. range (i.e. 4:1 turndown) by positioning the coarse span jumper (yellow plastic removable piece) on the appropriate pin connectors on the PC board and fine tuning span and zero with the PC board potentiometers (blue). The PC board is accessible by unscrewing the electronics housing cover on one side of the dual compartment housing. The other compartment contains the integral junction box with terminal strip for electrical connections. For example: a Model 114 with range of 0-100 psi will be shipped calibrated 0-100 psi from factory. The customer can field adjust, as described above, to as low as 0-25 psi or to any span in between 25 and 100 psi.

The Model PX 114 voltage version is available in fixed ranges only. The zero and span pots are located inside electrical housing and accessible by unscrewing cover for fine tuning.

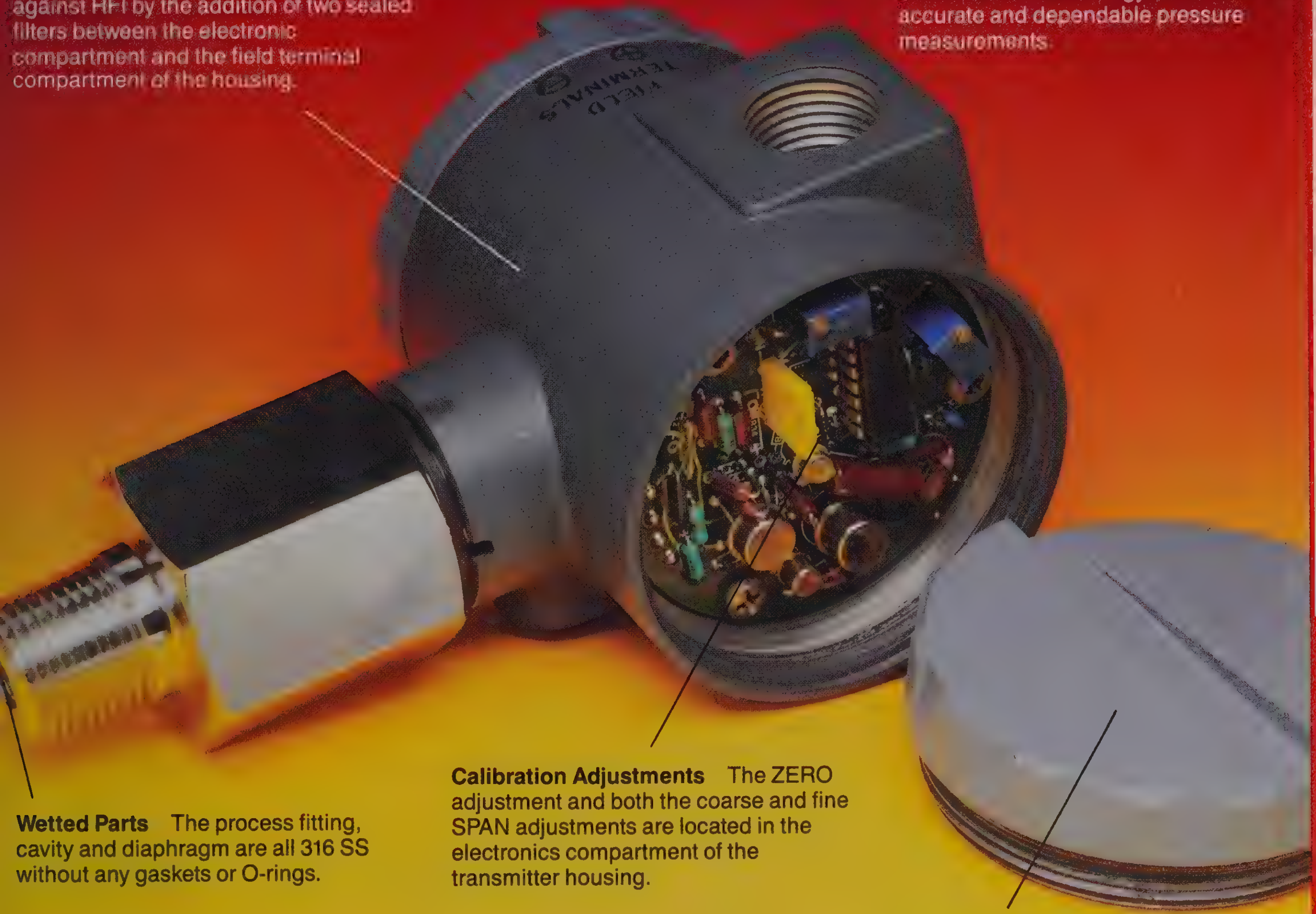
Excitation: 12.5 V dc to 36 V dc
Accuracy: ±0.5% of span (includes linearity, hysteresis, and repeatability)
Drift: (Over a 6-month period) Less than 0.5% of maximum span
Overrange Effect: Zero shift does not exceed ±0.05% of span when applying 1.5 times maximum span.
Ambient Temperature Effect: The total effect (maximum effect at any point on scale) as a percent of maximum span per 30°C (50°F) change is as follows:

$425

MAXIMUM TEMPERATURE EFFECT

−30 to 0°C (−20 to +30°F)	0 to 50°C (30 to 130°F)	50° to 80°C (130 to 180°F)
±1.2%	±0.75%	±1.0%

COMPLETELY FIELD SCALEABLE CURRENT OUTPUT



RFI The transmitter is protected against RFI by the addition of two sealed filters between the electronic compartment and the field terminal compartment of the housing.

Reliable The PX114 utilizes integrated circuit sensor technology to deliver accurate and dependable pressure measurements.

Wetted Parts The process fitting, cavity and diaphragm are all 316 SS without any gaskets or O-rings.

Calibration Adjustments The ZERO adjustment and both the coarse and fine SPAN adjustments are located in the electronics compartment of the transmitter housing.

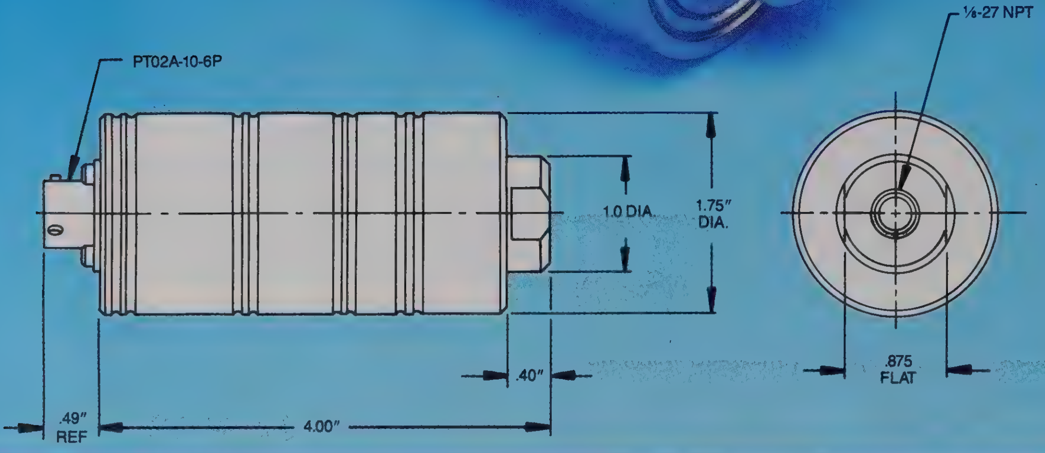
Nonwetted Parts Electronic housing and covers, low copper die-cast aluminum alloy finished with vinyl paint. The covers are threaded and seat on Buna-N O-rings.

To Order *(Specify model number)*

RANGE	VOLTAGE OUTPUT	PRICE	CURRENT OUTPUT	PRICE
0- 30 PSIG	PX 114-030G 5V	$425	PX 114-030G I	$425
◆ 0- 100 PSIG	PX 114-100G 5V	425 ◆	◆ PX 114-100G I	425 ◆
◆ 0- 300 PSIG	PX 114-300G 5V	425 ◆	◆ PX 114-300G I	425 ◆
◆ 0-1000 PSIG	PX 114-1KG 5V	425 ◆	◆ PX 114-1KG I	425 ◆
0-3000 PSIG	PX 114-3KG 5V	425	PX 114-3KG I	425

◆ *HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY* ◆

HIGH ACCURACY PRESSURE TRANSMITTER



841 Series
4-20 mA Output
0-5 To 0-5,000 PSI

- 0.25% Accuracy
- All Stainless Steel Construction

From **$515**

MATING CONNECTOR SEE PAGE C-4

To Order *(Specify model number)*

RANGE	MODEL	PRICE
0- 5 PSIG	PX-841-005G-I	$845
◆ 0- 10 PSIG	PX-841-010G-I	845 ◆
0- 15 PSIG	PX-841-015G-I	845
0- 20 PSIG	PX-841-020G-I	845
◆ 0- 25 PSIG	PX-841-025G-I	845 ◆
0- 50 PSIG	PX-841-050G-I	830
0- 100 PSIG	PX-841-100G-I	830
0- 200 PSIG	PX-841-200G-I	830
◆ 0- 250 PSIG	PX-841-250G-I	830 ◆
0- 350 PSIG	PX-841-350G-I	830
◆ 0- 500 PSIG	PX-841-500G-I	830 ◆
0- 750 PSIG	PX-841-750G-I	830
◆ 0-1000 PSIG	PX-841- 1 KG-I	515 ◆
0-1500 PSIG	PX-841- 1.5KG-I	515
0-2000 PSIG	PX-841- 2 KG-I	515
◆ 0-2500 PSIG	PX-841- 2.5KG-I	515 ◆
0-3000 PSIG	PX-841- 3 KG-I	515
0-5000 PSIG	PX-841- 5 KG-I	515

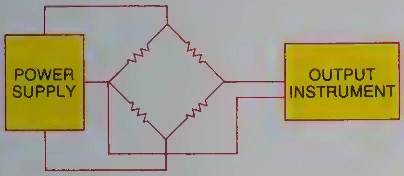
◆ *HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY* ◆

PERFORMANCE CHARACTERISTICS	
Accuracy	.25% worst case
Terminal Linearity	±0.15% FSO
Hysteresis	±0.10% FSO
Repeatability	±0.05% FSO
Stability	Less than 0.25% FSO over 6 months
Resolution	Infinite
TEMPERATURE CHARACTERISTICS	
Storage Temperature Range	−50°F to 250°F (−46°C to 121°C)
Operating Temperature Range	−20°F to 185°F (−29°C to 85°C)
Compensated Temperature Range	0°F to 150°F (−18°C to 66°C)
Thermal Effect on Zero	±0.3% FSO per 100°F
Thermal Effect on Sensitivity	±0.3% FSO per 100°F
ELECTRICAL CHARACTERISTICS	
Excitation	12 to 36 V dc
Full Scale Output	4-20 mA
Input Current	38 mA typical current limited
Zero Adjustment	−2.5%/+5.0% FSO
Gain Adjustment	±5%

HOW TO SELECT A PRESSURE SYSTEM

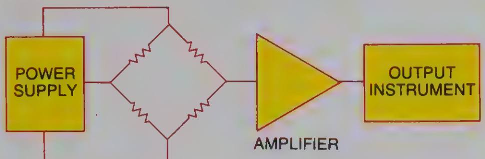
1. DEFINE THE TYPE OF SYSTEM:

BRIDGE


POWER SUPPLY
OUTPUT INSTRUMENT

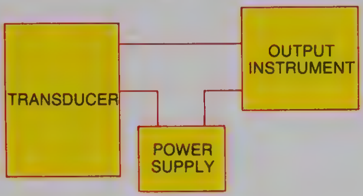
- Low Cost
- OEM Applications
- mV Output

CONDITIONED


POWER SUPPLY
AMPLIFIER
OUTPUT INSTRUMENT

- Easy Interface
- Long Distances
- Voltage Output

PROCESS LOOP


TRANSDUCER
POWER SUPPLY
OUTPUT INSTRUMENT

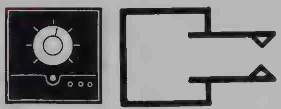
- Process Control
- Noisy Environments
- Current or Frequency Output

2. CHOOSE THE OUTPUT INSTRUMENT:

READOUT

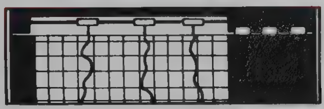
- **199 Series** page D-5
- **DP-350** page D-9
- **DP-420** page D-4

CONTROLLER



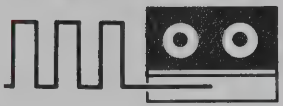
- **CN-25** page D-14
- **I921** page D-15
- **OM-3,4** page D-26

RECORDER



- **640** page D-16
- **555** page D-17
- **CT-400** page D-18

COMPUTER INTERFACE



- **μMEGA** page D-22
- **WB-31** page D-24
- **PLUG-IN** page D-28

3. SELECT THE PROPER TRANSDUCER:

USE THE MATRIX ON PAGES B-39 & 40 AS A GUIDE FOR

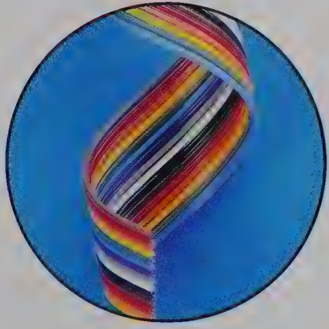
TYPE	PROCESS PORT	STYLE	OUTPUT CONNECTION
Bridge	Tubing	Silicon Diaphragm	Wire Leads
Conditioning	M or F Pipe	Stainless Steel	Connector
Process Loop	Flush Mount	Plastic Housing	PC Mount

4. PUT THE SYSTEM TOGETHER:

CONNECTORS

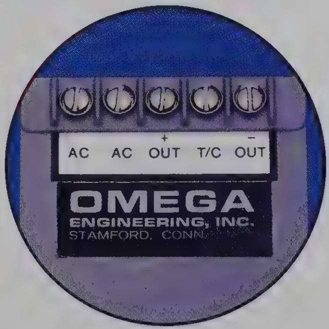
page
C-4

WIRE



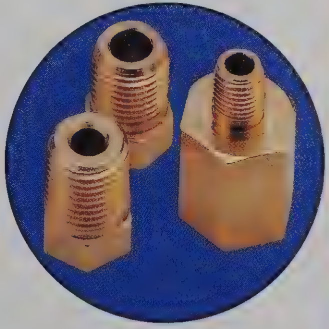
page
C-6

POWER SUPPLY

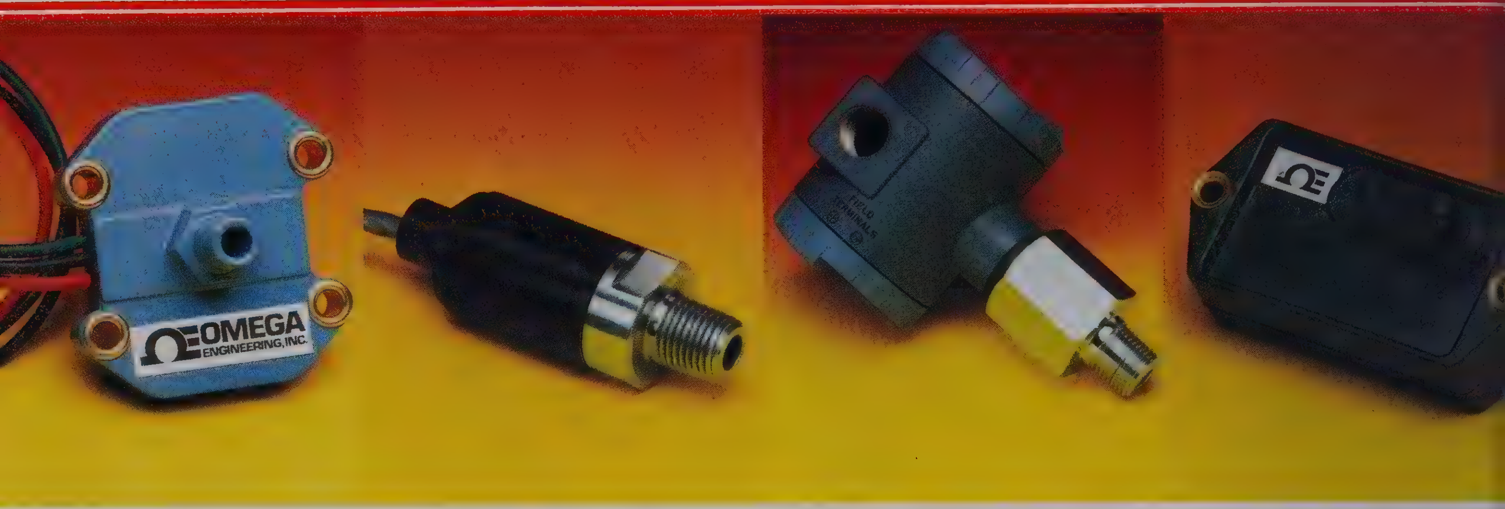

AC AC + OUT T/C − OUT
OMEGA
ENGINEERING, INC.
STAMFORD, CONN.

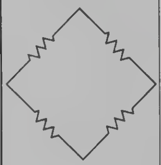
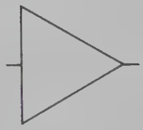
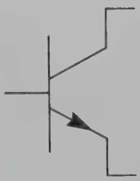
page
C-7

HARDWARE

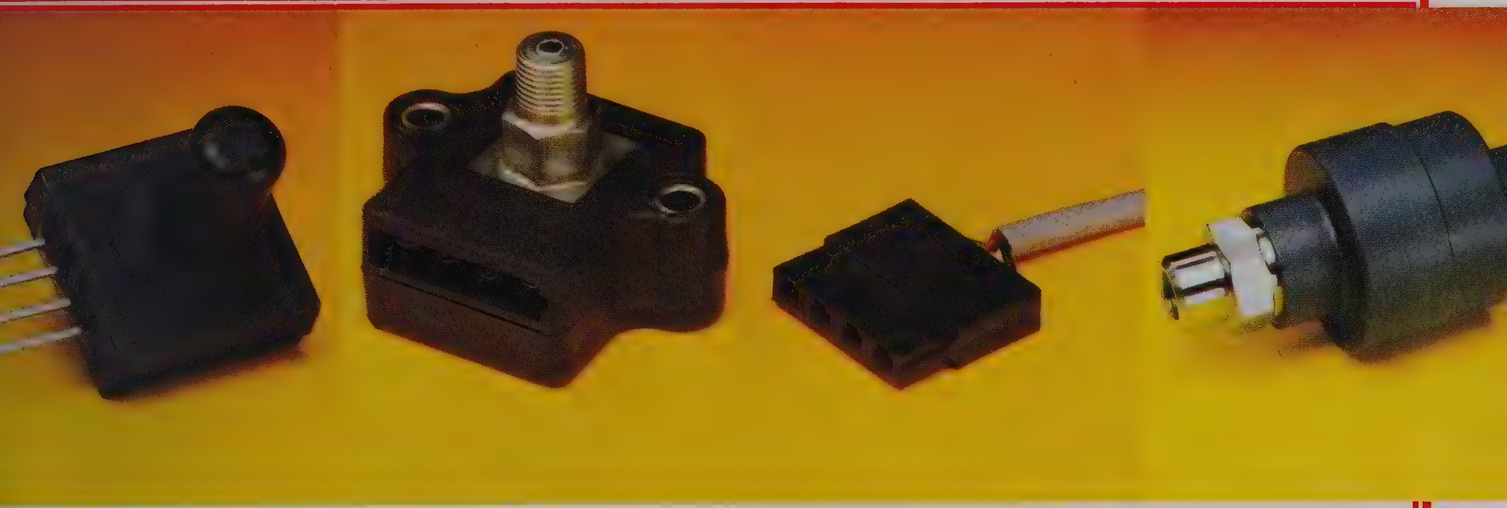


pages
C-10,18



			INPUT PARAMETERS		
	PAGE	SERIES	RANGES	CONNECTION	CASE/DIAPHRAGM
 **BRIDGE TYPE**	B-9	PX-100	0-15 to 0-5000 PSIG	¼-18 NPT	17-4 PH
	B-14	PX-102	0-6 to 0-20000 PSIG	FLUSH	15-5 PH
	B-4	PX-126	0-5, 0-15 PSID	TUBES	PLASTIC/SILICON
	B-3	PX-136	0-5 PSIG, 0-15 PSIA	TUBE	PLASTIC/SILICON
	B-7	PX-230	0-15 to 0-100 PSIG	¼-18 NPT	SS, EPOXY/SILICON
	B-5	PX-300	0-150 to 0-7000 PSIG	¼-18 NPT	SS, EPOXY/SS
	B-10	PX-301	0-50 to 0-5000 PSIG	¼-18 NPT	SS/17-4 PH
	B-6	PX-302	0-50 to 0-5000 PSIG	¼-18 NPT	SS, EPOXY/SS
	B-8	PX-304	0-50 to 0-300 PSIA	¼-18 NPT	17-4 PH
	B-11	PX-306	0-300 to 0-7500 PSIG	½-20 UNF-F	ALUMINUM & SS/17-4 PH
	B-12	PX-831	0-5 to 0-5000 PSIG, S,A	⅛-27 NPT-F	303, 304SS/17-4, 15-5 PH
 **AMPLIFIED OUTPUT**	B-25	PX-027	0-30 to 0-3000 PSIG	½ NPT	316 SS
	B-26	PX-105	0-6 to 0-2000 PSIG	TUBE, ⅛ NPT	VALOX/SS
	B-24	PX-110	0-15 to 0-3000 PSIA, G	¼-18 NPTF	ALUMINUM/316 SS
	B-15	PX-140	0-5 to 0-30 PSIG, A, D	TUBE	PLASTIC/SILICON
	B-16	PX-160	0-10 to 0-27.7 IN H_2O	TUBE	PLASTIC/SILICON
	B-17	PX-176	0-15 to 0-5000 PSI	THREAD	SS/SS
	B-18	PX-240	0-5 to 0-250 PSIG	⅛-27 NPT	ALUMINUM/BUNA N, SS
	B-19	PX-303	0-50 to 0-10000 PSIG	¼-18 NPT	17-4 PH
	B-20	PX-304	0-50 to 0-300 PSIA	¼-18 NPT	17-4 PH
	B-21	PX-500	0-15 to 0-5000 PSIG, A	¼-18 NPT	17-4 PH
	B-22	PX-510	0-5 to 0-10000 PSI	FLUSH	316L or 15-5 PH
	B-23	PX-851	0-5 to 0-5000 PSIG	⅛-27 NPTF	303, 304SS/17-4, 15-5 PH
 **LOOP OUTPUT**	B-33	PX-027	0-30 to 0-3000 PSIG	½-NPT	316SS
	B-27	PX-106	0-6 to 0-2000 PSIG	TUBE, ⅛ NPT	VALOX/SS
	B-34	PX-110	0-15 to 0-3000 PSIG	¼-18 NPT-F	ALUMINUM/316SS
	B-36	PX-114	0-30 to 0-3000 PSIG	½-NPT	ALUMINUM/316SS
	B-29	PX-149	3-15 PSI	TUBE	PLASTIC/SILICON
	B-30	PX-305	0-50 to 0-10000 PSIG	¼-18 NPT	17-4 PH
	B-28	PX-311	0-50 to 0-10000 PSIG	¼-18 NPT	SS/17-4 PH
	B-31	PX-420	0-15 to 0-5000 PSIG	¼-18 NPT	SS/17-4 PH
	B-32	PX-440	0-6 to 0-20000 PSIG	FLUSH	SS/15-5 PH
	B-37	PX-841	0-5 to 0-5000 PSIG	⅛-27 NPTF	303, 304SS/17-4, 15-5 PH

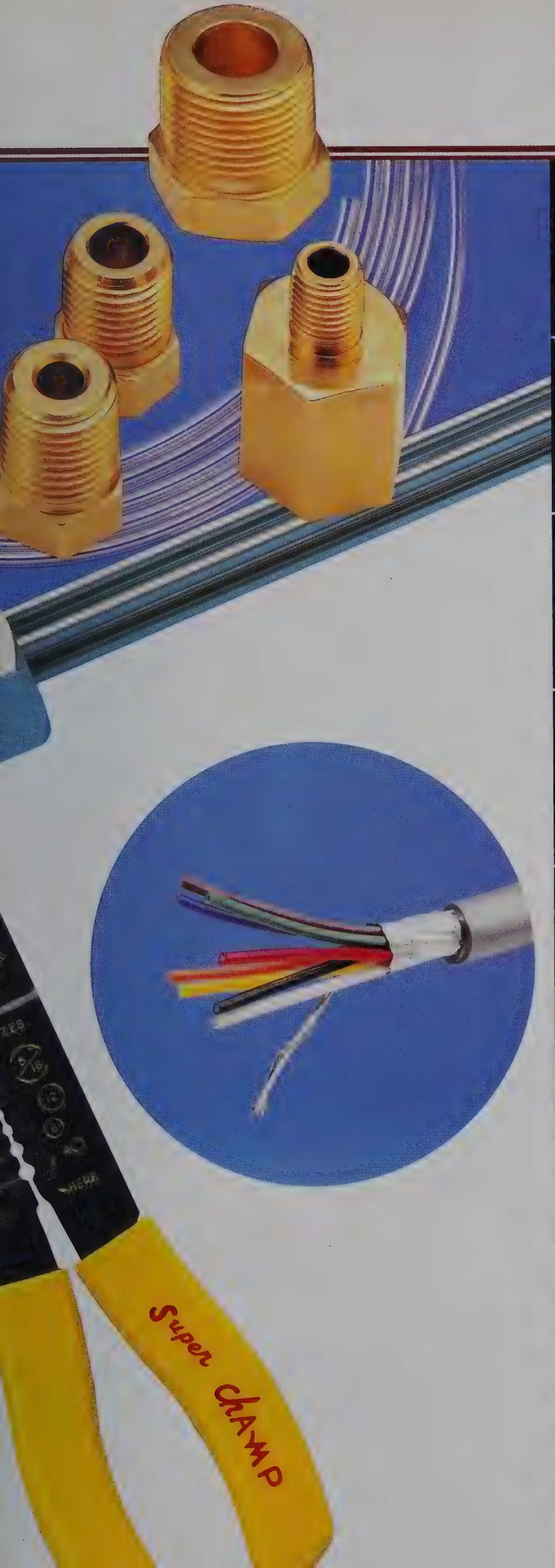
PRESSURE TRANSDUCER SELECTION GUIDE



OUTPUT PARAMETERS			FEATURES	SERIES	PAGE
EXCITATION	SIGNAL	TERMINATION			
10 V dc	0-100 mV	PT1H-8-4P	SOLID CONSTRUCTION	PX-100	B-9
5 V dc	0-100 mV	CABLE	GENERAL PURPOSE FLUSH MOUNT	PX-102	B-14
10 V dc	0-50, 0-100 mV	PINS	DIFFERENTIAL RANGE	PX-126	B-4
10 V dc	0-50, 0-100 mV	PINS	MINIATURE—LOW COST	PX-136	B-3
10 V dc	0-60 to 0-100 mV	CABLE	COMPACT DESIGN	PX-230	B-7
10 V dc	0-30 mV	CABLE	½ BRIDGE CIRCUIT	PX-300	B-5
10 V dc	0-100 mV	CABLE	GENERAL PURPOSE	PX-301	B-10
10 V dc	0-100 mV	CABLE	FULL BRIDGE CIRCUIT	PX-302	B-6
10 V dc	0-100 mV	CABLE	ABSOLUTE PRESSURES	PX-304	B-8
10 V dc	0-30 mV	PT1H-10-6P	FEMALE O-RING PRESSURE PORT	PX-306	B-11
10 V dc	0-30 mV	PT02A-10-6P	0.25% ACCURACY	PX-831	B-12
12.5-36 V dc	.5-5.5 V dc	LEADS	ZERO AND SPAN ADJUST	PX-027	B-25
8-20 V dc	1-6 V dc	CONNECTOR	QUICK CONNECT PLUG	PX-105	B-26
12.5-36 V dc	.5-5.5 V dc	LEADS	GAGE AND ABSOLUTE RANGES	PX-110	B-24
8 V dc	1-6 V dc	PINS	PC MOUNTING	PX-140	B-15
8 V dc	1-6 V dc	PINS	SCALED IN INCHES OF WATER	PX-160	B-16
9-20 V dc	1-6 V dc	CABLE	9 to 20 V dc EXCITATION	PX-176	B-17
8 V dc	1-6 V dc	LEADS	LOW PRESSURE RANGES	PX-240	B-18
14-32 V dc	0-5, 0-10 V dc	LEADS	WIDE EXCITATION RANGE	PX-303	B-19
12-32 V dc	0.5-5.5 V dc	LEADS	ABSOLUTE RANGES	PX-304	B-20
24-32 V dc	5 V dc	PT1H-8-4P	MALE PROCESS CONNECTION	PX-500	B-21
12-20 V dc	5 V dc	PT1H-10-6P	FLUSH PROCESS MOUNTING	PX-510	B-22
24-32 V dc	5 V dc	PT02A-10-6P	FEMALE PROCESS CONNECTION	PX-851	B-23
12-30 V dc	4-20 mA	LEADS	ZERO AND SPAN ADJUST	PX-027	B-33
10-20 v dc	1-6 K hz	CONNECTOR	QUICK CONNECT PLUG	PX-106	B-27
12-30 V dc	4-20 mA	LEADS	FRMALE PROCESS PORT	PX-110	B-34
12.5-36 V dc	4-20 mA/.5-5.5 V	SCREW	RUGGED INDUSTRIAL DESIGN	PX-114	B-36
10-40 V dc	4-20 mA	PINS	PROCESS PRESSURE TO CURRENT	PX-149	B-29
12-67 V dc	4-20 mA	CABLE	WIDE SUPPLY RANGE	PX-305	B-30
15-32 V dc	1-11 K hz	CABLE	FREQUENCY OUTPUT	PX-311	B-28
24-32 V dc	4-20 mA	PT1H-8-4P	NPT MOUNT 4-20 mA	PX-420	B-31
14-50 V dc	4-20 mA	PT1H-10-6P	FLUSH MOUNT 4-20 mA	PX-440	B-32
12-36 V dc	4-20 mA	PR02A-10-6P	HIGH ACCURACY .25%	PX-841	B-37

Ⓒ ACCESSORIES

AC
AC
+ OUT
T/C
− OUT
OMEGA
ENGINEERING, INC.
STAMFORD CONN
22-14
12-10

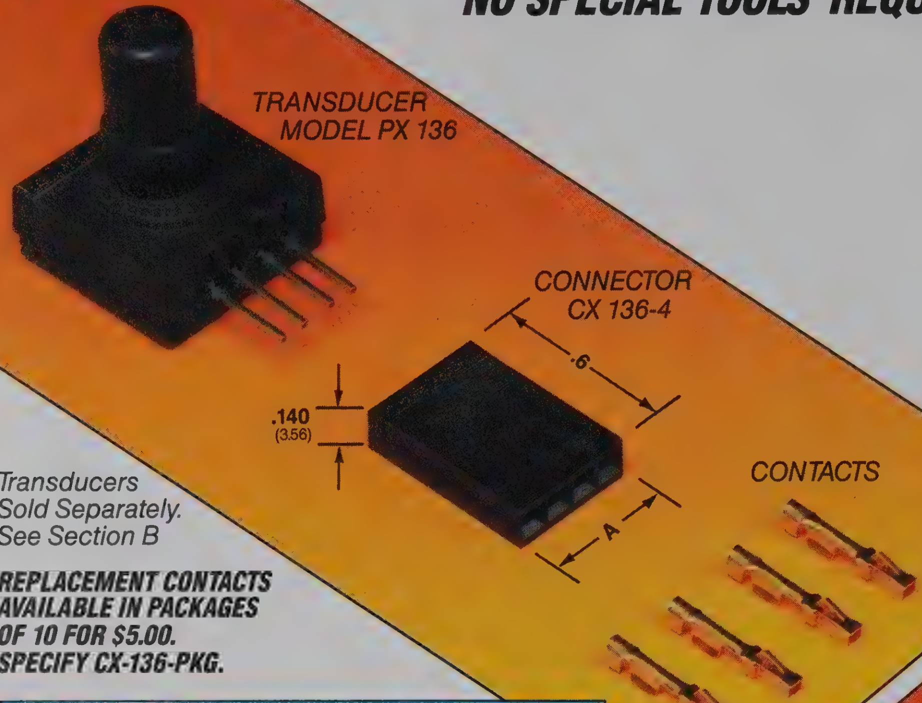


Connectors/Push on Style Crimp Contact	C-3
Connectors/Twist Lock	C-4
Crimper Terminals and Barrier Strips	C-5
Power Supplies	C-7
Tubing and Hose Clamps	C-9
Self-Sealing Plugs	C-10
Multi-Conductor Feedthroughs	C-11
Compression Fittings and Reducing Bushings	C-13, C-14

CONNECTORS
PUSH-ON STYLE, CRIMP CONTACT

NO SPECIAL TOOLS REQUIRED!

- Heavy Duty Construction
- Rated to 215°F (105°C)
- Solder/Crimp Contacts
- 22-26 AWG Wire Size
- Flame Retardant Thermoplastic Shells
- High Conductivity Gold Plated over Nickel Plated Contacts
- Contacts Included


TRANSDUCER MODEL PX 136
CONNECTOR CX 136-4
.6
.140
(3.56)
A
CONTACTS

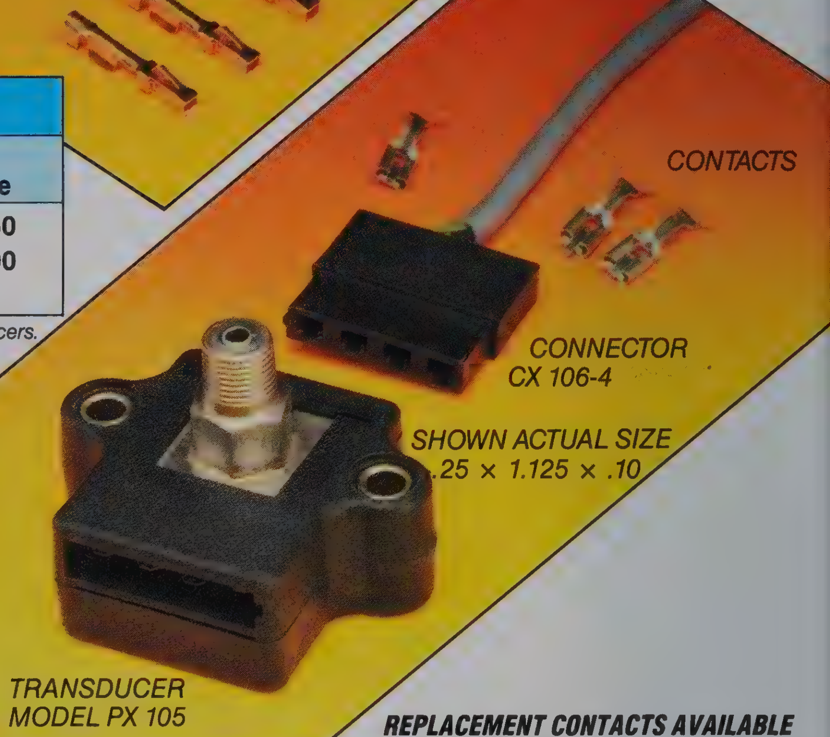
Transducers Sold Separately. See Section B

REPLACEMENT CONTACTS AVAILABLE IN PACKAGES OF 10 FOR $5.00. SPECIFY CX-136-PKG.

To Order *(Specify part number)*

Part No.	No. of Contacts	"A"	Price
CX-136-3	3	.305	**$2.50**
CX-136-4	4	.405	**3.00**
CX-136-8	8	.805	

NOTE: 3 Position used on PX-140, 160, & 240 Series Transducers.
4 Position used on PX-120, 130 Series Transducers.
8 Position used on PX-149 Transducers.


CONTACTS
CONNECTOR CX 106-4
SHOWN ACTUAL SIZE .25 × 1.125 × .10
TRANSDUCER MODEL PX 105

REPLACEMENT CONTACTS AVAILABLE IN A PACKAGE OF 10 FOR $1.25 PKG SPECIFY CX-105-PKG

OEM STYLE CONNECTORS FOR PX-105 AND PX-106 PRESSURE TRANSDUCERS

- Durable Valox Shell
- Rated to 257°F (125°C)
- Solder/Crimp Contacts
- 16-20 AWG Wire Size
- High Conductivity Tin Plated over Brass Contacts
- Contacts Included

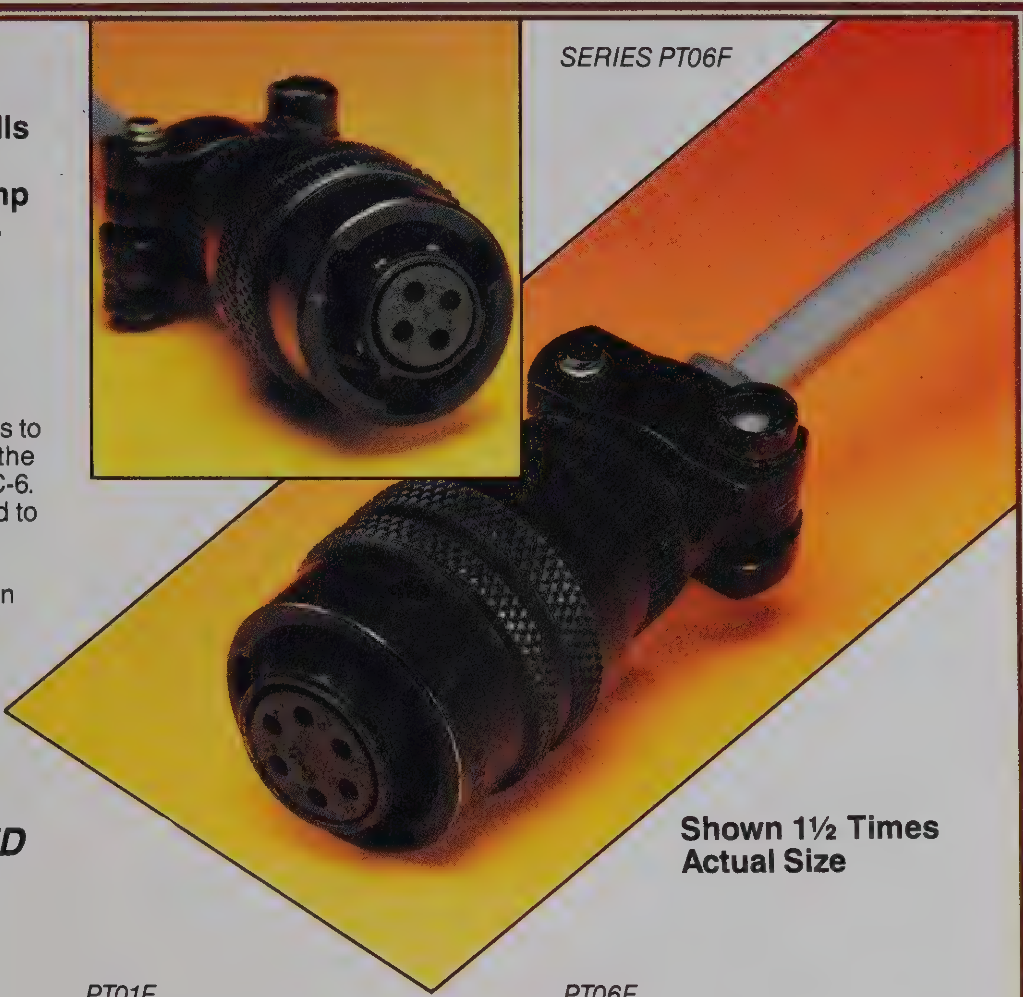
To Order *(Specify part number)*

Part No.	No. of Contacts	Price
CX-105-3	3	**$5**
CX-106-4	4	**5**

CONNECTORS
TWIST LOCK TYPE

- **Rugged Aluminum Shells**
- **Rated to 257°F (125°C)**
- **Strain Relief Cable Clamp**
- **Secure Solder Contacts**
- **#20 AWG Wire Size**
- **High Conductivity Gold Plated Contacts**

OMEGA PT Series Connectors provide an efficient method of connecting Pressure Transducers to associated instrumentation with the Multi-Conductor cable on page C-6. The solder contacts are designed to provide positive connections for signal or power circuitry. The connectors are rated for operation −67°F (−55°C) to 257°F (125°C).

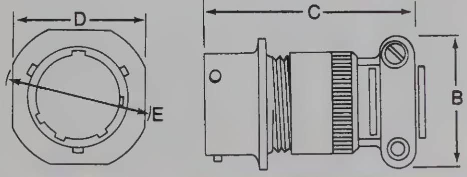


SERIES PT06F

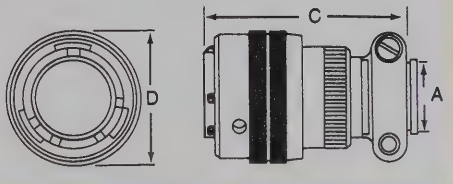
Shown 1½ Times Actual Size

INTEGRAL SOLDER CONTACTS INCLUDED

PT01F



PT06F



SPECIFICATIONS

Insulation Resistance at 77°F: 5000 megohms min.
Voltage Drop: #20 contact, #20 wire, at 7.5 A, 55 mV max.
Air Pressure: 30 psi at −55°C
Water Immersion: 6 ft., 48 hours
Durability: 500 cycles of coupling and uncoupling
Shells: Aluminum alloy, .0003 cadmium plate with olive drab chromate
Insulators: Neoprene
Contacts: High conductivity copper alloy, .000050 gold over copper.

To Order *(Specify part number)*

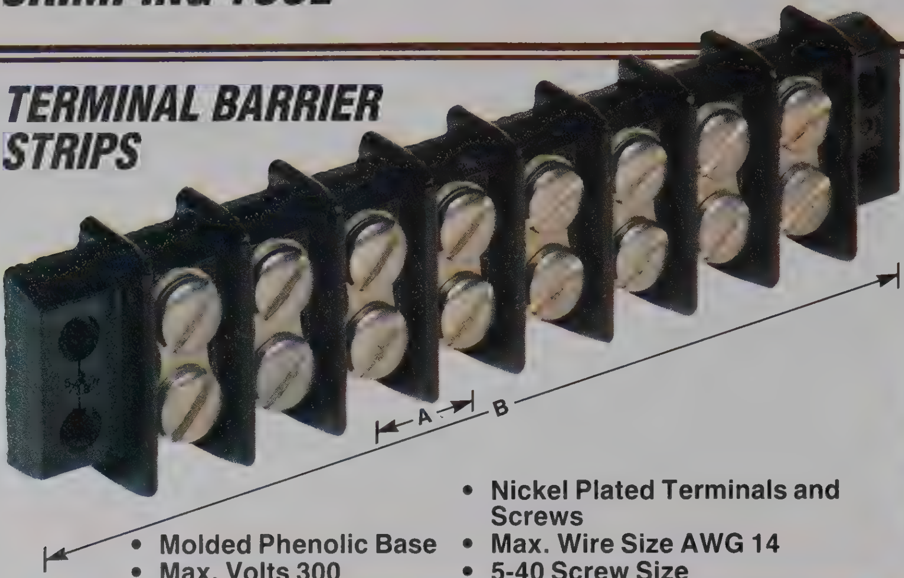
Part No.	No. of Contacts	Fits Transducer on Pg.	Price
PT01F- 8-4P	4	—	$18
PT01F-10-6P	6	—	24.50
PT06F- 8-4S	4	B-9, B-21, B-31	24
PT06F-10-6S	6	B-11, B-12, B-22, B-23, B-32, B-37	26.50

DIMENSIONS

	A Min. Dia.	B Max.	C Max.	D Max.	E ±.020
PT01F- 8-4P	.234	.828	1.922	.828	.938
PT01F-10-6P	.297	.891	1.922	.954	1.062
PT06F- 8-4S	.234	.828	1.828	.750	—
PT06F-10-6S	.297	.891	1.828	.859	—

INSULATED SOLDERLESS TERMINALS TERMINAL BARRIER STRIPS CRIMPING TOOL

TERMINAL BARRIER STRIPS



- Molded Phenolic Base
- Max. Volts 300
- Nickel Plated Terminals and Screws
- Max. Wire Size AWG 14
- 5-40 Screw Size

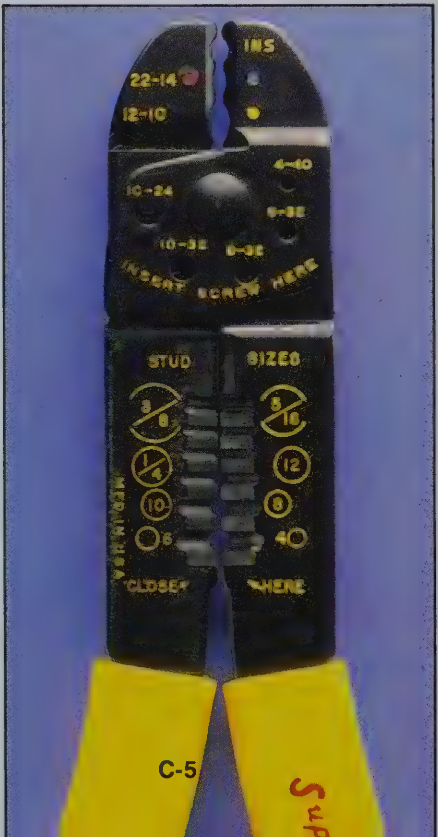
To Order *(Specify catalog number)*

CATALOG NO.	NO. OF TERMINALS	DIMENSIONS (IN.)		STRIP PRICE EACH
		A	B	
MBS2	2	1⅛	1 13/32	$1
MBS4	4	1⅞	2 5/32	2
MBS6	6	2⅝	2 29/32	2
MBS8	8	3⅜	3 21/32	3
MBS10	10	4⅛	4 13/32	3
MBS12	12	4⅞	5 5/32	4
MBS16	16	6⅜	6 21/32	5
MBS20	20	7⅞	8 5/32	6

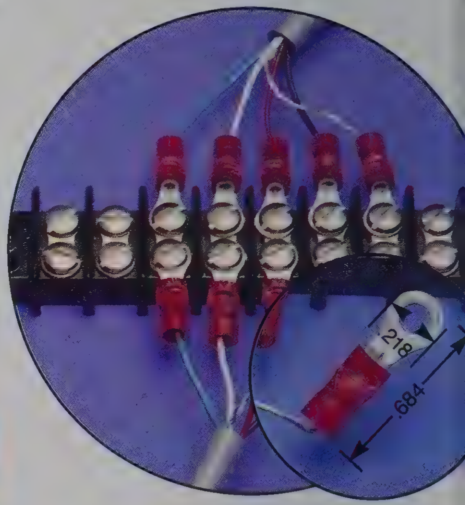
CRIMPING TOOL FOR SOLDERLESS TERMINALS

- Cuts bolts, crimps solderless terminals, cuts wires, strips wires
- Contoured, cushioned handle

The crimping tool is manufactured from high quality carbon tool steel processed through "austempering" heat treatments. Austempering means that the tool is virtually free of distortion and quench cracks. It will resist wear, bending, and breakage because it is stronger and tougher than most comparable types.



INSULATED SOLDERLESS TERMINALS



The pre-insulated solderless terminals have been designed specifically to answer the need for inexpensive but fully insulated terminations.

To Order:

Solderless Terminals
Wire Range 26-22 AWG
for #6 screw
Pkg. of 100

Part No.	Price
ST-100	$20.00

$20
CT-100 CRIMP TOOL

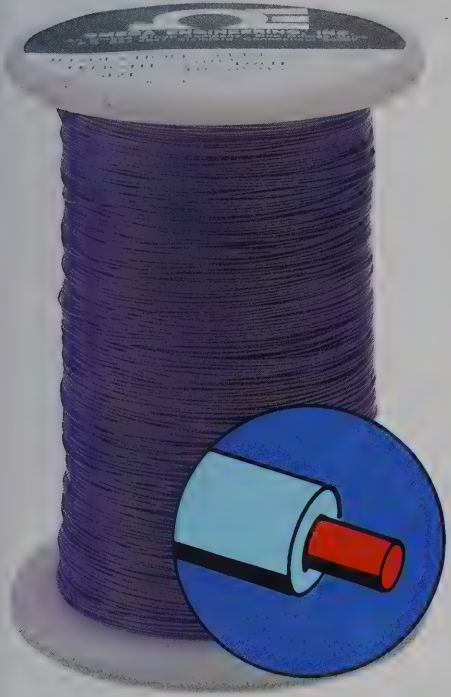
To Order:

Crimp Tool

Part No.	Price
CT-100	$20.00

WIRE AND CABLE

FINE GAGE .005″ DIA. SINGLE WIRE



- 3 Mil Teflon Wall
- Single Strand
- Extruded PFA (Teflon)
- Excellent in Vacuum
- Non-flammable

OMEGA'S thin-wall covering process guarantees continuous lengths up to 1,000 feet. This wire is ideal for connecting the strain gages to solder terminal strips and pads.

Price Table	
Spool Size	**Price**
50 Ft.	**$11.00**
100 Ft.	**21.50**
500 Ft.	**85.00**

To Order *(Specify catalog number)*

Dia.	Length Ft.	Cat. No.	Price
.005	50	TFCP-005- 50	**$11.00**
.005	100	TFCP-005-100	**21.50**
.005	500	TFCP-005-500	**85.00**
.010	50	TFCP-010- 50	**11.00**
.010	100	TFCP-010-100	**21.50**
.010	500	TFCP-010-500	**85.00**
.015	50	TFCP-015- 50	**11.00**
.015	100	TFCP-015-100	**21.50**
.015	500	TFCP-015-500	**85.00**

MULTI-CONDUCTOR RIBBON CABLE

- 28 AWG Stranded Conductors
- PVC Rating to 105°C
- Color Coded
- 100 Foot Rolls

OMEGA'S ribbon cables are PVC preinsulated conductors laminated to a clear PVC film to allow easy termination. The color coding allows for quick identification and circuit tracing. The multi-conductor ribbon cable can be easily trimmed to any desired conductor width for different uses.

To Order *(Specify catalog number)*

No. of Cond.	Cat No.	Price 100 ft
4	RC- 4-100	**$ 42.00**
10	RC-10-100	**31.00**
14	RC-14-100	**44.00**
16	RC-16-100	**50.00**
26	RC-26-100	**81.00**
50	RC-50-100	**155.00**

All Wire Stocked For Immediate Delivery

MULTI-CONDUCTOR SHIELDED CABLE

- 24 AWG Tinned Copper Wires
- PVC Insulation
- Aluminum-Polyester Shield with #24 Drain Wire
- PVC Jacket Overall
- 100 Foot Rolls

Shielded cable provides the high conductivity and noise immunity required for instrumentation hook-ups to transducers. It is suitable for low and high level voltage signals and mA pick-up in high EMI/RFI environments.

To Order *(Specify catalog number)*

No. of Cond.	Nom. O.D.	Cat. No.	Price 100 ft.
4	.190″	TX- 4-100	**$28.50**
8	.220″	TX- 8-100	**43.50**
15	.280″	TX-15-100	**88.00**

CONVENIENT PRE-SPOOLED LENGTHS

REGULATED POWER SUPPLIES
PIN TERMINAL STYLE

For Socket or Printed Circuit Mounting

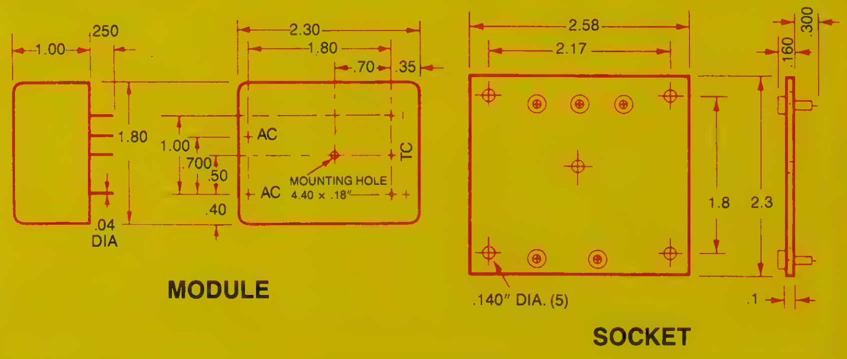
- No Derating or Heat Sinking Required
- Short Circuit Protected
- Small, Lightweight
- Completely Sealed Case
- Only 7 oz.

From
$85
MODEL PSP-10

Socket Board Sold Separately.
Order Part No. OMX-P5 $10

MODEL
R15P250
SERIAL NO
PS 1283
CALIBRATION
5V @ 500 mA
AMPS
VOLTAGE
110
OMEGA
ENGINEERING, INC.
Stamford, CT 06907

Shown actual size


1.00
.250
1.80
.04
DIA
2.30
1.80
.70
.35
1.00
.700
.50
.40
AC
AC
TC
MOUNTING HOLE
4.40 × .18"
MODULE
2.58
2.17
.300
.160
1.8
2.3
.140" DIA. (5)
.1
SOCKET

DIMENSIONS IN INCHES

To Order *(Specify model number)*

OUTPUT		MODEL	PRICE
V	mA		
5	250	PSP-5	$100
8	150	PSP-8	100
10	120	PSP-10	85
15	150	PSP-15	110
28	40	PSP-28	100

ALL MODELS STOCKED FOR FAST DELIVERY

To Order Accessory Socket: Specify OMX-P5 $10
These sockets have a sturdy phenolic base with gold plated Teflon-insulated contacts.

COMMON POWER SUPPLY SPECIFICATIONS

Input Voltage: 105-125 V ac, 47 to 420 Hz, single phase
Output: See tables
Regulation: .05% line
.05% load
Ripple: 0.5 mV rms
Output Voltage Trim Adjustment: Output is factory preset to ±2% (1 to 9 volt models) or ±1% (10 to 75 volt models) of nominal output voltage. Output may be trimmed to the nominal voltage rating with an external trim resistor.
Polarity: Output is floating. Either positive or negative terminal may be grounded.
Ambient Operating Temperature: −20 to +71°C. No derating required.
Storage Temperature: −55 to +85°C
Temperature Coefficient: From 9 to 75 volts, approximate TC is .015%/°C; 1 to 8 volts, .03%/°C
Impedance: 0.07 ohms at 1 kHz and 0.2 ohms at 10 kHz (approx.)

SELECT THE VOLTAGE OUTPUT TO MATCH YOUR TRANSDUCER OR RESISTANCE BRIDGE.

EXCITATION FOR STRAIN GAGES BRIDGES AND PRESSURE TRANSDUCERS
SCREW TERMINAL STYLE

For Easy Field Termination without Soldering

- 4-40 Screw Terminations and Mounting Inserts
- Floating Output
- Efficient
- Rugged
- 15 oz.

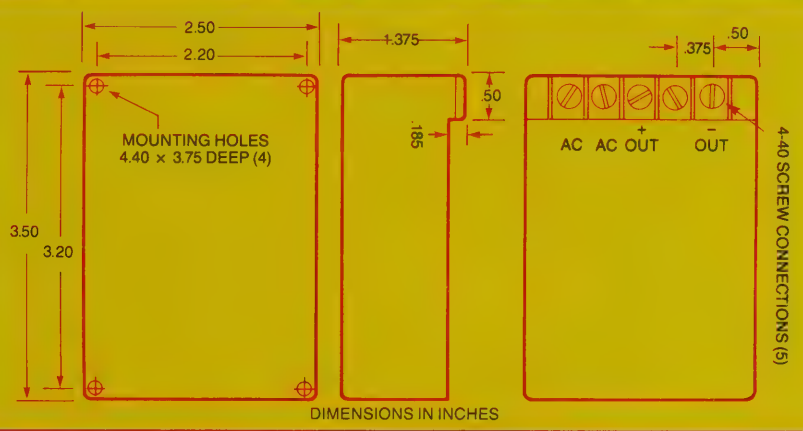
AC
AC
OUT
T/C
OUT
OMEGA
ENGINEERING, INC.
STAMFORD, CONN.

From
$135
MODEL PST-5

Shown actual size

Encapsulated Power Supplies provide a versatile excitation source for transducers and bridges. Two case styles are available for your installation needs. The pin terminal style can either be soldered into a printed circuit board or plugged into a phenolic accessory socket board with gold plated Teflon insulated contacts. A 4-40 threaded insert is molded into the power supply case to provide a means of securing the module without stressing the connection pins. The barrier strip type case is designed to be mounted to a bulkhead or chassis using four 4-40 screws. Screw terminals are provided for connection using either crimp lugs or stripped wires.

These regulated power supplies are designed to be a modular solution for your excitation needs. The stable output allows drift-free performance even if the input power source is noisy or unstable. Long term measurements can then be meaningfully compared with confidence. Short circuit protection prevents failure due to excessive current drain and the conservative design assures long term reliability.



DIMENSIONS IN INCHES

To Order *(Specify model number)*

OUTPUT		MODEL	PRICE
V	mA		
5	500	PST-5	$135
8	300	PST-8	135
10	240	PST-10	135
15	200	PST-15	135
28	150	PST-28	165

ALL MODELS STOCKED FOR FAST DELIVERY

FLEXIBLE PLASTIC TUBING
MINIATURE STAINLESS STEEL CLAMPS

$20
100 FT. ROLL

Stainless Steel Clamps
One size fits all. **$15**

- **Temperature Range −49°F to 165°F**
- **Lightweight, Flexible**
- **Low Working Pressure**
- **Readily Curves Around Corners**
- **Flexibility Saves Footage**

Lightweight, flexible and easy to handle, PVC flexible plastic tubing goes into service fast. It is readily curved around corners and obstructions, requiring a minimum of couplings and fittings. Its flexibility can save up to one-third the footage and much of the labor required to install rigid tubing.

Only the simplest of tools and equipment are required to put the tubing into service. It is readily cut with any sharp knife.

Stainless Steel Hose Clamps
Range: ¼″ to ⅝″

Where pressures are involved, it is considered "good practice" to use clamps on all connections between tubing and fittings. Although the tubing grips tightly to such fittings, clamps provide an added safety factor.

SPECIFICATIONS

Color: Clear
Durometer Hardness (Shore A) ASTM D2240: 63
Tensile Strength: 2300 psi (162 kg/cm^2)
Maximum Recommended Operating Temperature: 165°F (74°C)
Low Temperature Brittleness by Impact: −49°F (−45°C)
Steam Autoclaving Conditions: 30 min. @ 15 psi (1.1 kg/cm^2)
Elongation: 410%
Odor: None
Taste: None
Toxicity: Non-Toxic
Dielectric Strength (Rapid Rise Method): 385 v/mil (151 v/cm)

Chemical Resistance

Strong Acids: Good
Weak Acids: Excellent
Strong Alkalies: Good
Weak Alkalies: Excellent

Inside Diameter		Outside Diameter		Wall Thickness		Maximum Suggested Working Pressure at Room Temperature	
Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	psi	kg/cm^2
³⁄₁₆	4.76	⁵⁄₁₆	7.94	¹⁄₁₆	1.59	51	3.5
¼	6.35	⅜	9.53	¹⁄₁₆	1.59	51	3.5

To Order *(Specify catalog number)*

Flexible Plastic Tubing

ID	Catalog No.	100 ft. Roll	Use on Pressure Transducer Models
³⁄₁₆″	TY-316-100	**$20**	Series 126, 136, 140, 160
¼″	TY- 14-100	**25**	Series 136

STAINLESS STEEL CLAMPS		
Pkg. of	Part No.	Price
10	CP-10	**$15**

PRESSURE & TEMPERATURE TEST PLUGS

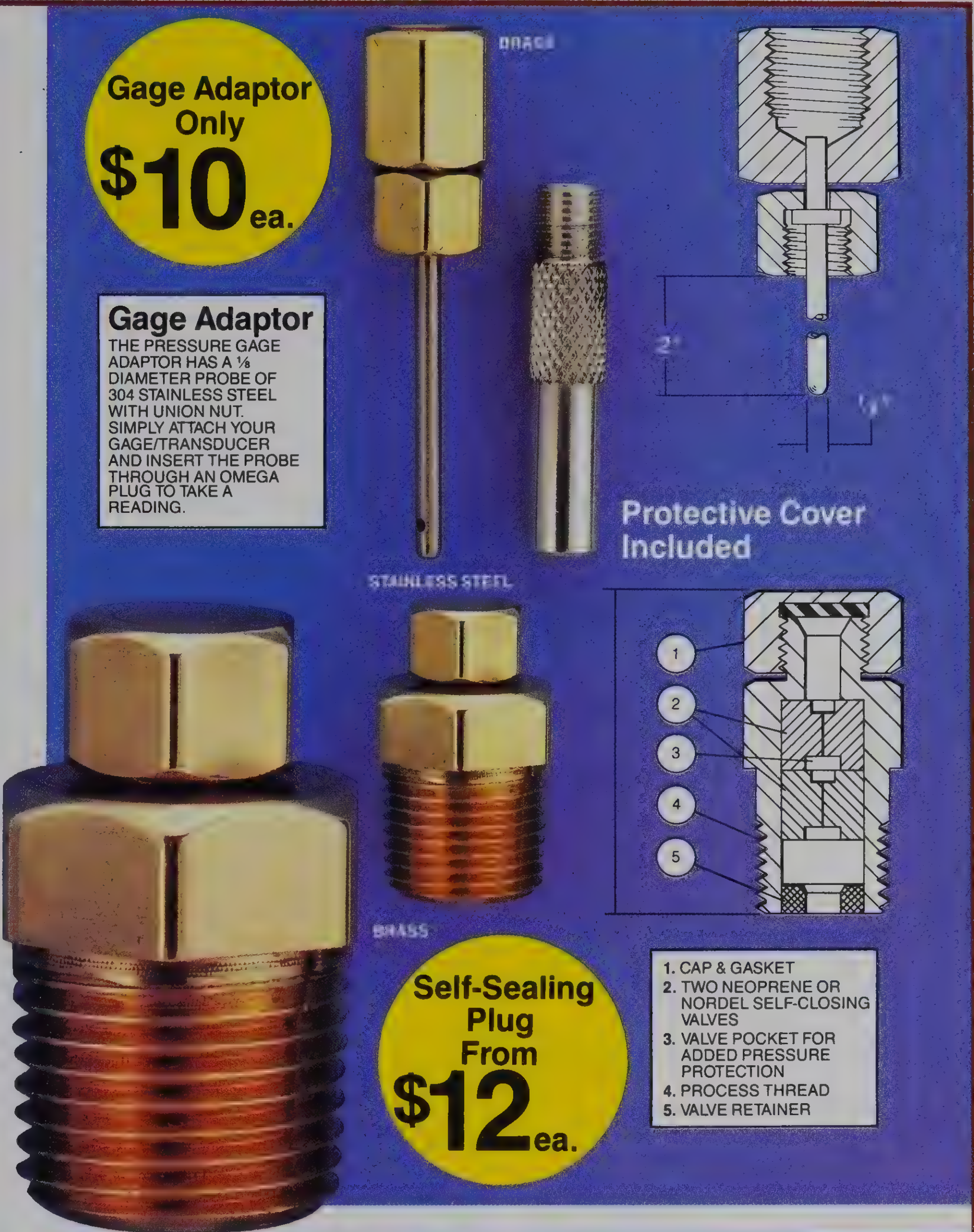
OMEGA® SELF-SEALING

- **Up to 1,000 PSIG between −20°F and 140°F**
- **Up to 275°F**
- **Two Self-Closing Valves**
- **Heavy Duty Design**

OMEGA® Self-Sealing Plugs will allow you to take pressure and temperature readings quickly, and eliminate the need for leaving costly gages or temperature indicators on the line. The OMEGA plug is permanently installed in the line at recommended test points. The cap protects the valve and provides an additional positive seal. After the cap has been removed, either a test thermometer or a gage adaptor with the proper pressure gage attached can be inserted through the two self-closing valves in the plug. Readings are made, adjustments or tests can be accomplished, and when the probes are withdrawn, the two valves close. The protective cap is then reinstalled.

Neoprene is resistant to deterioration from waxes, oils, greases, fats, petroleum products, and most refrigerants. Can be operated at a maximum temperature of 200°F at 500 PSIG.

Nordel gives excellent service in hot or cold water and in some applications of low pressure steam. Nordel is resistant to detergents, phosphates, esters, ketones, alcohols, and glycols. It is not suitable for petroleum products. Can be operated at a maximum temperature of 275°F at 500 PSIG.



Gage Adaptor Only $10 ea.

Gage Adaptor

THE PRESSURE GAGE ADAPTOR HAS A 1/8 DIAMETER PROBE OF 304 STAINLESS STEEL WITH UNION NUT. SIMPLY ATTACH YOUR GAGE/TRANSDUCER AND INSERT THE PROBE THROUGH AN OMEGA PLUG TO TAKE A READING.

Protective Cover Included

1. CAP & GASKET
2. TWO NEOPRENE OR NORDEL SELF-CLOSING VALVES
3. VALVE POCKET FOR ADDED PRESSURE PROTECTION
4. PROCESS THREAD
5. VALVE RETAINER

Self-Sealing Plug From $12 ea.

- **Any Size Plug Accepts up to a 1/8" Dia. Probe**

To Order *(Specify part number)*

OMEGA Plug

PART NO.	NPT MALE	VALVE CORE MATERIAL	PRICE
OPNE-14	1/4"	NEOPRENE	**$12.00** ea.
OPNO-14	1/4"	NORDEL	**13.50** ea.
OPNE-12	1/2"	NEOPRENE	**15.50** ea.
OPNO-12	1/2"	NORDEL	**17.00** ea.

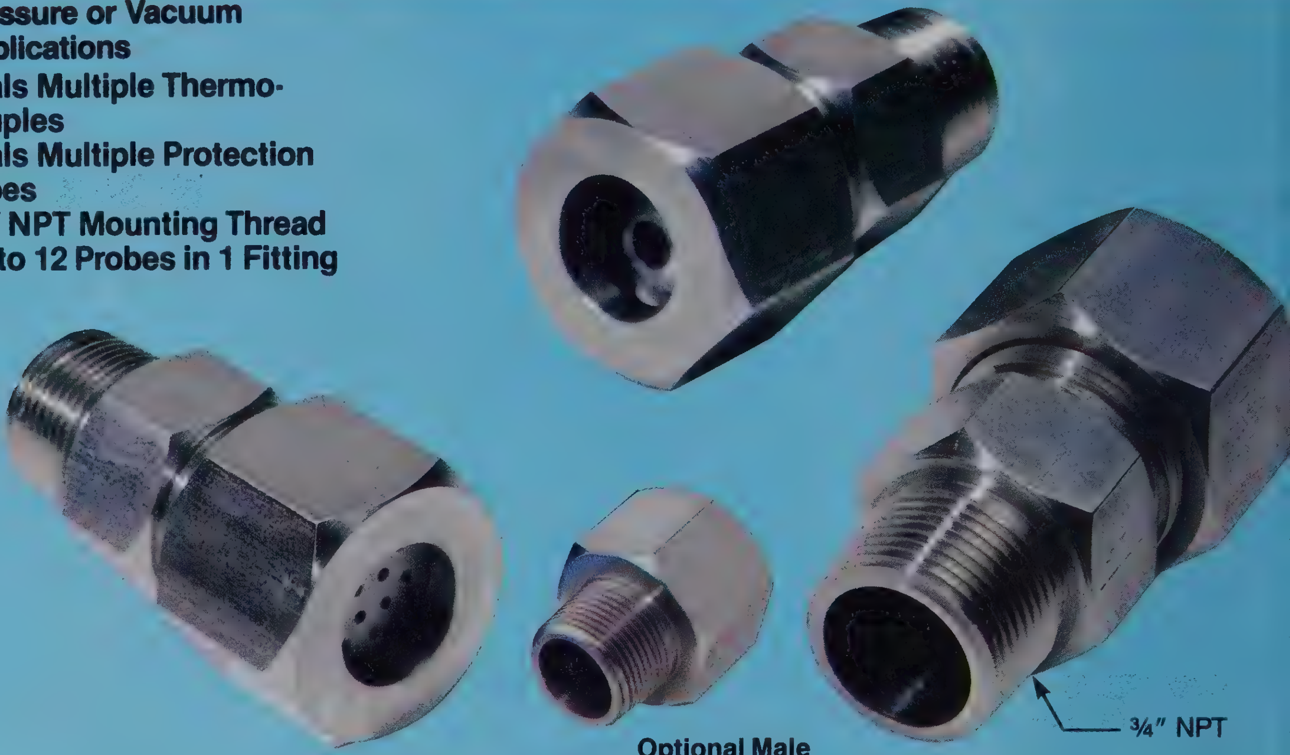
Gage Adaptor

PART NO.	NPT FEMALE	PROBE DIA.	PRICE
GASS-18	1/4"	1/8"	**$10.00** ea.

IN STOCK FOR IMMEDIATE DELIVERY!

MULTICONDUCTOR FEEDTHROUGHS

- Pressure or Vacuum Applications
- Seals Multiple Thermocouples
- Seals Multiple Protection Tubes
- ¾″ NPT Mounting Thread
- Up to 12 Probes in 1 Fitting



Optional Male Threaded Cap

FOR OTHER STYLES SEE PAGE C-14

To Order *(Specify catalog number)*

¹⁄₁₆″ SHEATHS

Number Openings	Catalog Number	Price Each
1	FT-116- 1	**$ 65**
2	FT-116- 2	**72**
3	FT-116- 3	**79**
4	FT-116- 4	**87**
5	FT-116- 5	**95**
6	FT-116- 6	**103**
7	FT-116- 7	**111**
8	FT-116- 8	**119**
9	FT-116- 9	**127**
10	FT-116-10	**135**
11	FT-116-11	**143**
12	FT-116-12	**151**

⅛″ SHEATHS

Number Openings	Catalog Number	Price Each
1	FT-18-1	**$61**
2	FT-18-2	**67**
3	FT-18-3	**73**
4	FT-18-4	**79**
5	FT-18-5	**85**
6	FT-18-6	**91**
7	FT-18-7	**97**

OPTIONAL MALE THREADED CAP

Catalog Number	Price Each
FTN-1	**$25**

³⁄₁₆″ SHEATHS

Number Openings	Catalog Number	Price Each
1	FT-316-1	**$63**
2	FT-316-2	**69**
3	FT-316-3	**75**
4	FT-316-4	**81**
5	FT-316-5	**87**

¼″ SHEATHS

Number Openings	Catalog Number	Price Each
1	FT-14-1	**$63**
2	FT-14-2	**69**
3	FT-14-3	**75**

MULTICONDUCTOR FEEDTHROUGHS

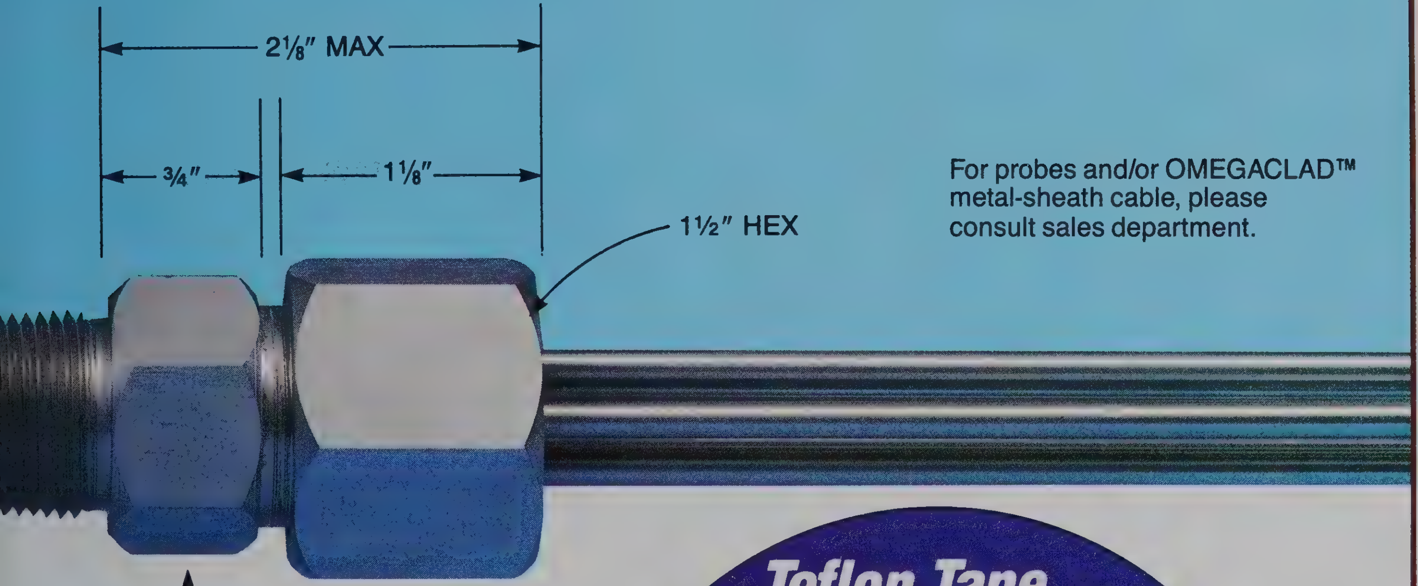
COMPRESSION-TYPE FOR VACUUM OR PRESSURE SEALING

These all new multiconductor feedthroughs are designed for use in applications that require several sensors to pass through a wall or bulkhead at one opening or within a small area. Heavy duty 416 stainless steel construction allows this fitting to be used in high pressure or vacuum applications. Probes between 1/16″ diameter and ¼″ diameter may be used in these feedthroughs. The maximum number of probes per feedthrough is 3 for ¼″ diameter, 5 for 3/16″ diameter, 7 for ⅛″ diameter, and 12 for 1/16″ diameter probes.

All multiconductor feedthroughs are supplied in standard form with stainless steel ferrules. A stainless steel ferrule deforms and becomes permanent. If it is required that the probes be installed several times at different depths in the feedthrough, Teflon ferrules should be used. Teflon ferrules will not deform the probe sheath, allowing the same probe to be reused. The ferrules used in the feedthroughs are identical to the ferrules used in the standard OMEGALOK™ compression fittings.

- **1 to 12 Probes**
- **416SS Body and Cap**
- **316SS Ferrules Standard**
- **Teflon Ferrules Available**
- **Uses Standard OMEGALOK™ Ferrules**
- **1/16″ Through ¼″ Diameter Probes**

For probes and/or OMEGACLAD™ metal-sheath cable, please consult sales department.



Replacement Ferrules

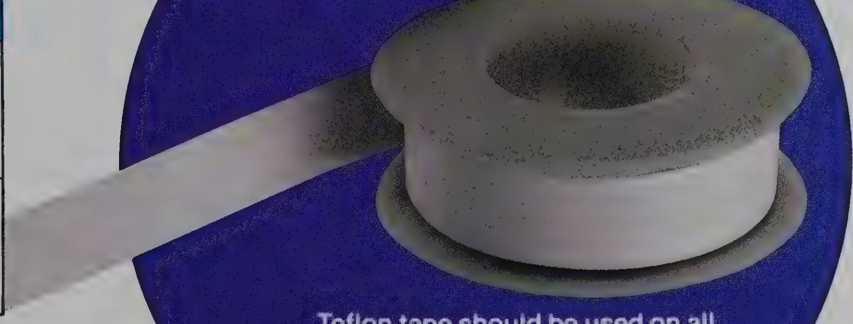
Material	Dia.	Catalog Number	Price /10
Teflon	1/16 ⅛ 3/16 ¼	T-FER-1/16 T-FER-⅛ T-FER-3/16 T-FER-¼	$40
316SS	1/16 ⅛ 3/16 ¼	SS-FER-1/16 SS-FER-⅛ SS-FER-3/16 SS-FER-¼	$30

Supplied in a Package of 10

NOTE: All fittings are supplied standard with stainless steel ferrules. If Teflon ferrules are required, add suffix-Teflon to the part number shown. Add $10 to cost.

Teflon Tape

½″ x 260″



Teflon tape should be used on all pipe joints to provide a good seal and to prevent the threaded parts from seizing each other on disassembly. **$3.50/roll**

D INSTRUMENTATION
FOR PRESSURE AND STRAIN MEASUREMENTS

PROCESS CONTROLLER
+1400
OUT 1
OUT 2
RESET
MODE
OMEGA
PROCESS CONTROLLER
+1.974
PROCESS CONTROLLER
+1800
OMEGA 880 DIGITAL MULTIMETER
88.0
OMEGA 881F DIGITAL MULTIMETER
88.1
DCA
TEMP
ACA
COM
mA
V-Ω
COM-500V MAX
TYPE K TC
NiCr-NiAl
10A HI
500V MAX
OPERATE
STANDBY
AUTO
OMEGA ENGINEERING, INC
0
10
20
30
40
50
60
70
80
90
POWER

Controllers

Data Loggers

Hand helds

Panel Meters
Recorders
AC LINE MONITOR
CALIBRATED RANGE
+115 V
OMEGA ENGINEERING MODEL 199G
SIGNAL MONITOR
RMS
+224 V
OMEGA ENGINEERING MODEL 199H
mV
OMEGA

Precision Industrial Displays D-3
TX-81 Industrial Current Loop Indicator D-10
800 Series Thermocouple, Thermistor and Multimeter Models D-11
PC-2500 Strain Gage/Recorder Interface D-12
Multifunction Process Controllers D-13
Series 920 Digital, Analog and Non-indicating Models D-15
1, 2 and 3 Channel mV Recorders D-16
Chart Temp™ Battery and Spring Wound Recorders D-18
Data Logger D-19
Computer Interface D-21
Modular Signal Conditioners and Alarms D-25
Interface Card Kits D-27

DIGITAL TRANSDUCER INDICATORS

Rugged Industrial Indicator

Model
DP-420-1
$599
420
OMEGA
Transducer Indicator 420
ZERO

Transducers sold separately. See Section B

SPECIFICATIONS

Resolution:
1 part in 10,000

Sensitivity:
Adjustable from 1 to 120 microvolts per count

Long Term Accuracy:
After 24 hours, ±0.02% of full scale or ±0.03% of reading. 1 year, ±0.1% of full scale.

Repeatability:
±3 millivolts or ±0.01% of range, whichever is greater

Input Type:
Grounded or floating transducer, 4 or 6 wire connection

To Order *(Specify model number)*

MODEL	PRICE	DESCRIPTION
◆ DP 420-1 115/250 V ac	$599	0 to 9999 count with built-in adjustable excitation power supply panel mount hardware and owners manual. ◆
OPTIONS		
0001 0002	$ 35 165	Front Panel Tare/Zero Adjust Knob BCD Output

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

Model DP 420

- **Pressure Transducers**
- **Load Cells**
- **Torque and Force Transducers**
- **Other Full-Bridge Strain Gage Devices with mV/V Outputs.**
- **Rugged Metal Case**

The OMEGA Series 420 Digital Transducer Indicator is a precision instrument for displaying, in engineering units, the equivalent output of low level voltage signals from strain gage devices. It is completely self-contained from excitation source to digital readout; you don't have to buy and add on amplifiers, signal conditioners, excitation sources, etc. Just connect the output from your strain gage device (pressure transducer, load cell, etc.) and plug the indicator line-cord into a power outlet.

The OMEGA Series 420 Indicator can be used to monitor thrust, torque, pressure, force, weight, and other physical phenomena, directly in engineering units. Typical O.E.M. applications for weighing systems are: bench, counter, conveyor, platform, railroad, and truck scales. Typical applications for Instrumentation Engineers are: pressure indicators, laboratory force testers, hardness and compression testers, load cell systems, and dynamometers.

Transducer (Load Cell) Input. Connections are made at a six terminal barrier strip on the rear. Two terminals are for the excitation source, two terminals are for remote sensing (not required but provides greater system accuracy when used), and two are for signal input which has a 2-pole, 10 Hz, input filter. Transducers with bridge resistance from 120 to 2000 ohms have no effect on performance.

Overload Indication. When the input exceeds the preset value, the indicator will display all dashes (---).

DIGITAL TRANSDUCER INDICATORS

Rugged Industrial Indicator

Model DP 420

19″ RACK PANELS AVAILABLE—CONSULT SALES DEPT.

FEATURES

TRANSDUCER EXCITATION:
Selectable for 7.5, 10, 15 or 20 V dc

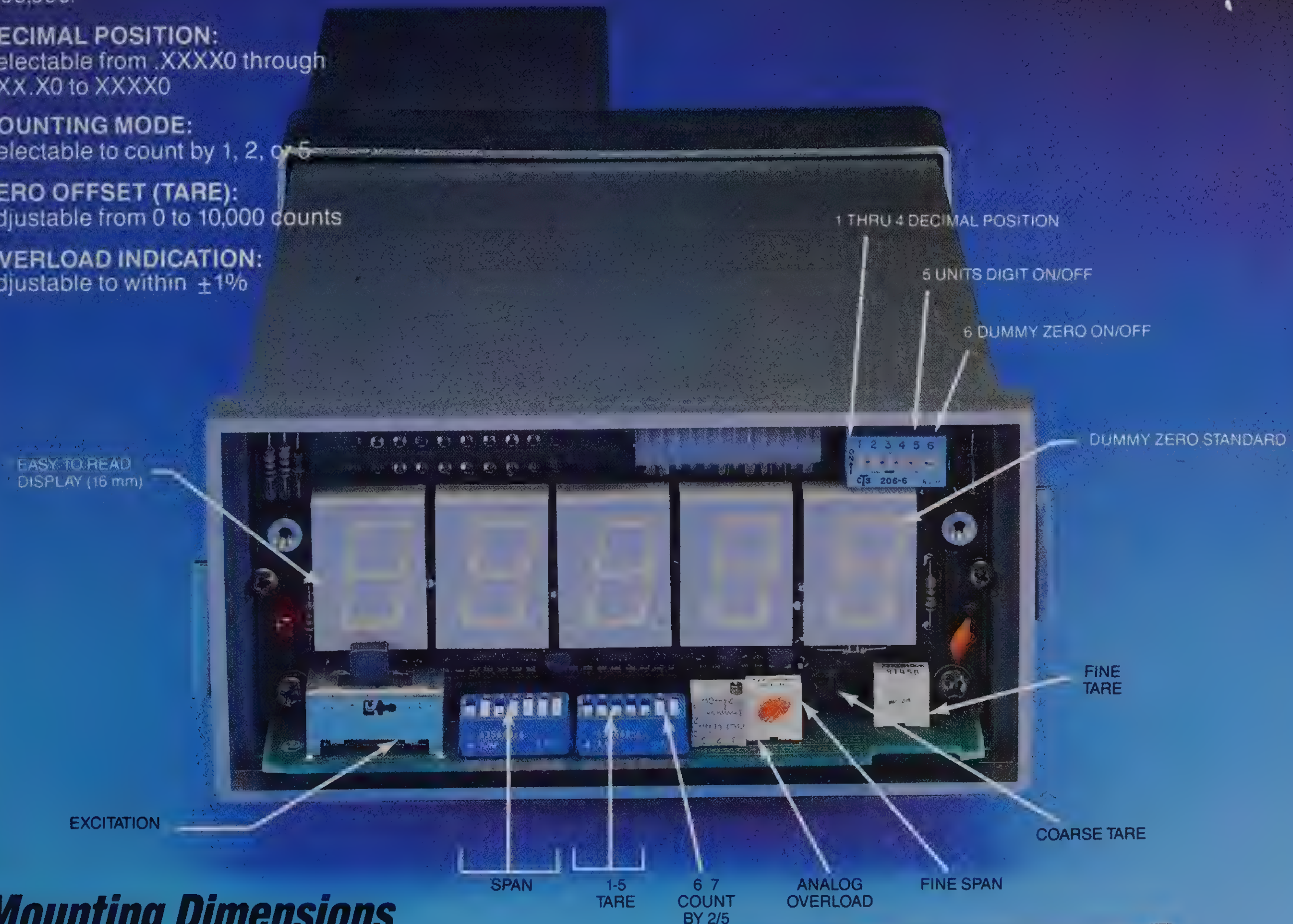
FULL SCALE DISPLAY:
Selectable display up to ±9,999 counts, includes dead zero for display up to ±99,990.

DECIMAL POSITION:
Selectable from .XXXX0 through XXX.X0 to XXXX0

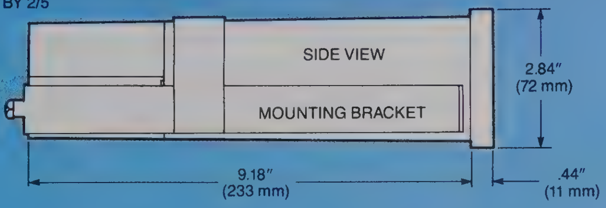
COUNTING MODE:
Selectable to count by 1, 2, or 5

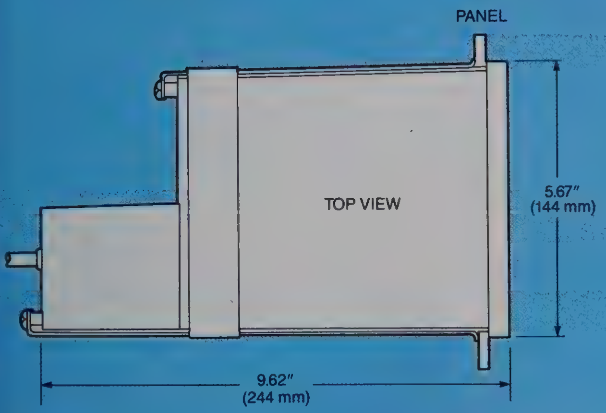
ZERO OFFSET (TARE):
Adjustable from 0 to 10,000 counts

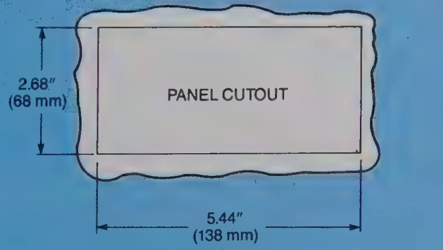
OVERLOAD INDICATION:
Adjustable to within ±1%


1 THRU 4 DECIMAL POSITION
5 UNITS DIGIT ON/OFF
6 DUMMY ZERO ON/OFF
DUMMY ZERO STANDARD
EASY TO READ DISPLAY (16 mm)
FINE TARE
EXCITATION
COARSE TARE
SPAN
1-5 TARE
6 7 COUNT BY 2/5
ANALOG OVERLOAD
FINE SPAN

Mounting Dimensions


SIDE VIEW
MOUNTING BRACKET
2.84″ (72 mm)
9.18″ (233 mm)
.44″ (11 mm)


PANEL
TOP VIEW
5.67″ (144 mm)
9.62″ (244 mm)


PANEL CUTOUT
2.68″ (68 mm)
5.44″ (138 mm)

DIGITAL TRANSDUCER INDICATORS

Model 199J Strain Gage Pressure Monitor

Features

- Front Panel Display in Engineering Units
- Switch Selectable Gain
- Excitation Voltage Included
- Zero Offset Adjust Standard
- High Impact Plastic Case
- ±1999 Counts Full Scale

350 Ω TRANSDUCER INPUT
PRESSURE
236
OMEGA ENGINEERING MODEL 199J
OMEGA ENGINEERING, INC.
242PC100G
8331

$328
199J-SG

Transducers Supplied Separately

Strain Gage

The 199J supplies an excitation of 10 volts for use with strain, pressure or force bridges having a minimum resistance of 350 ohms. Both offset and gain are adjustable for the 5 mV to 30 mV full scale input.

SPECIFICATIONS

199J

Input Signal: 1.4 V dc max.
Input Protection: ±100 V dc or ac
Input Filter: 5 Hz switchable on/off
CMV: ±1500 V dc or peak ac, line to analog ground
Input Impedance: > 1,000 MΩ
Input Bias Current: < 100 pA
Excitation Voltage: 5 V dc for transducers with resistance ≥ 350Ω, floating, isolated, and short protected.
Hookup: 4-wire or 6-wire, includes 2-wire differential excitation, sense, and provision for connections to calibrating resistor at transducer in place of excitation sense.
Cable Length: 6-wire plus shield, for remote sense operation. Up to 1000 feet of #26 AWG length, or one-way resistance of less than 40 ohms for rated performance.

INPUT

Scaling: Range 1:
Range 2:
Offset: Range 1: 0 to ±1.5 mV/V
Range 2: 0 to ±5.7 mV/V
Accuracy: ±0.05% FS ±1 count
Gain: DIP switch selectable from 0.27 to 362

THE MODEL 199J WORKS WITH OMEGA TRANSDUCERS: SEE SECTION B

To Order *(Specify model number)*

MODEL	PRICE	DESCRIPTION
▶ 199J-SG	**$328**	115 V ac power standard ◀
Other Models—with longer deliveries.		
199J-SG-A	**$358**	199J with analog output 1000 counts = 1 V
Power Option—Will cause longer deliveries.		
220 V ac	**N/C**	220 V ac input power

▶ HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY ◀

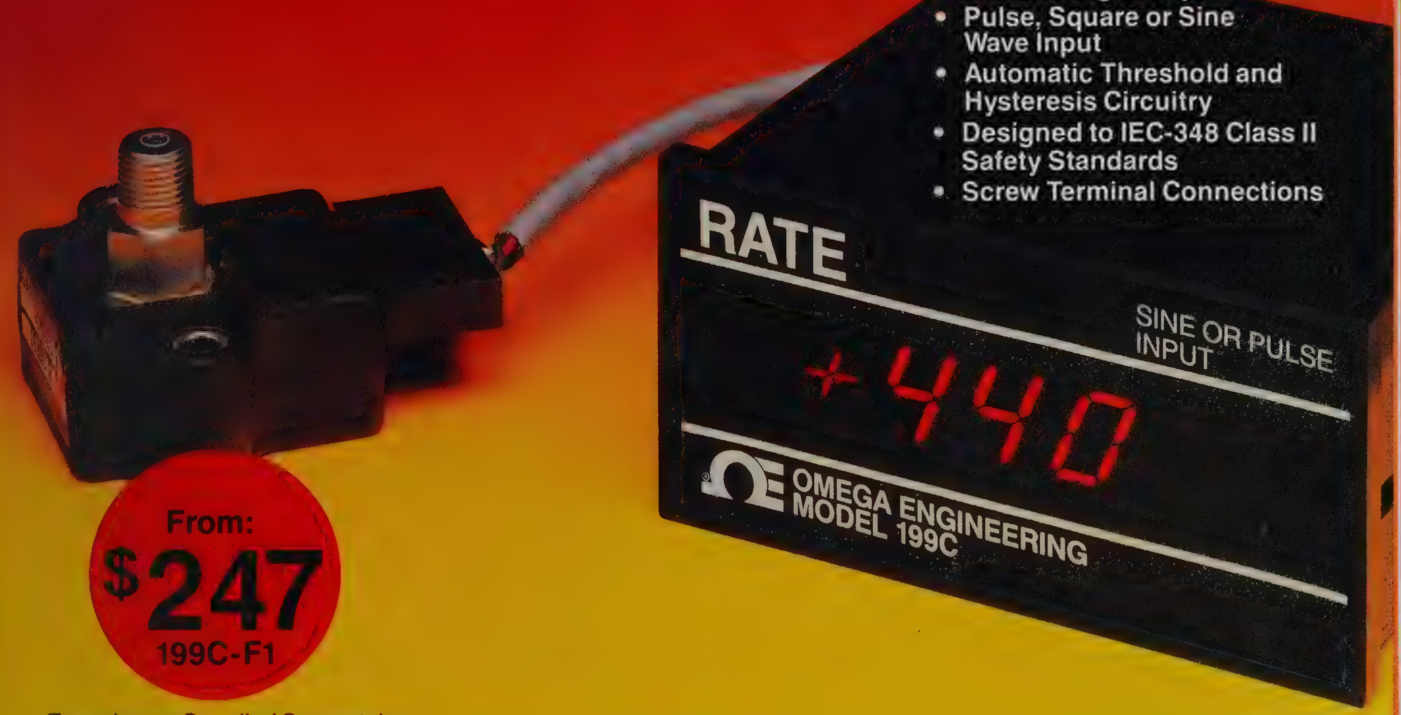
DIGITAL TRANSDUCER INDICATORS

Model 199C Rate Monitor

For Pressure to Frequency Transducers

Features

- Display Range Switch Selectable
- Isolated Signal Input
- Pulse, Square or Sine Wave Input
- Automatic Threshold and Hysteresis Circuitry
- Designed to IEC-348 Class II Safety Standards
- Screw Terminal Connections



From:
$247
199C-F1

Transducers Supplied Separately

FREQUENCY INPUT

The 199C can display preselected engineering units of rate, strain, pressure, frequency, or percentage. Front panel accessible switches provide on-site setup of the input signal span, data averaging and pulse output.

SPECIFICATIONS

SIGNAL INPUT

User selectable for sinewave or pulse input (See below)
Configuration: Two wire, floating and isolated, dc coupled
Input Resistance: 33 kΩ in parallel with 100 pF
Bias Current: 50 nA typ.
Input Frequency: to 10 kHz
Input Protection: ±300 V dc or ac rms continuous without damage

SINE WAVE INPUT

Input Voltage: 6 mV pp. to 300 V pp. Sensitivity decreases @ 40 dB/decade > 1 kHz

PULSE INPUT

Polarity: Pulses to be positive with respect to signal return
Input Voltage: 1.5 V to 100 V
Threshold Level: 1 V nom.
Pulse Width: 50 μs min.

COMMON MODE

SIGNAL INPUT TO ANALOG GROUND

Common Mode Voltage (CMV): ±2000 V dc or ac peak
Common Mode Rejection Ratio (CMMR): 100 dB @ 50 or 60 Hz

ac POWER LINE TO ANALOG GROUND

Common Mode Voltage (CMV): ±1400 V dc or ac peak (B Version with printed circuit connection fingers); ±3000 V dc or ac peak (standard)

THE MODEL 199C WORKS WITH OMEGA TRANSDUCERS: ON PAGES B-27, B-28

To Order *(Specify model number)*

MODEL	PRICE	DESCRIPTION
◆ 199C-F1	$247	115 V ac power standard ◆
Other Models—with longer deliveries		
199C-F1-A	$277	with analog output
199C-F1-D	277	with BCD output
199C-F1-AD	307	with analog and BCD output
Power Options		
Specify: 5 V dc, 8-28 V dc, or 220 V ac		

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

DIGITAL TRANSDUCER INDICATORS

Model 199D Current Loop Receiver

CURRENT LOOP
MONITOR
INPUT RANGE
4 To 20 mA
+704
OMEGA ENGINEERING
MODEL 199D

Features:

- Wide Range Front Panel Span Selection—60 to 3800 Counts F (4 to 20 mA)
- Zero Offset ±1999 Counts
- Floating Input with respect to ac Power Ground Eliminates Ground Loops
- Overcurrent Indication Blanks Display Except Polarity
- Designed to IEC-348 Class II Safety Standards
- All Screw-Terminal Connections

199D
$232

Transducers Supplied Separately

CURRENT LOOP

Interfacing with a pressure transducer with a current output, the 199D converts inputs ranging from 0 to 20 mA, 4 to 20 mA, 0 to 50 mA or 10 to 50 mA into the engineering units required by your application.

To Order *(Specify model number)*

MODEL	INPUT	PRICE	DESCRIPTION
◆ 199D-I2	4-20 mA	**$232**	115 V ac power standard ◆
Other Models			
199D-I1	0-20 mA	**$232**	115 V ac power standard
199D-I3	0-50 mA	**232**	115 V ac power standard
199D-I4	10-50 mA	**232**	115 V ac power standard
Options			
A	—	**$30**	Analog output
D	—	**30**	BCD output
Power	—	**N/C**	Specify 5 V dc 8-28 V dc, 220 V ac

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

SPECIFICATIONS

SIGNAL INPUT

Input Current Range: 0 to 20 mA, 4 to 20 mA, 0 to 50 mA, 10 to 50 mA
Input Impedance: 50Ω @ 20 mA; 20Ω @ 50 mA
Input Current (max.): 70 mA for 20 mA FS ranges; 110 mA for 50 mA FS ranges
Input Voltage Drop: IV Compliance @ 20 or 50 mA
Overcurrent Indication: 20% above FS, Display blanks except for polarity
Normal Mode Rejection Ratio: 65 dB typ. @ 50 or 60 Hz

COMMON MODE

Input Signal to ac Line: ±1400 V dc or ac peak (B Version); ±3000 V dc or ac peak
Common Mode Rejection Ratio: 120 dB

PERFORMANCE

Resolution: 0.05% @ 1999 counts
Accuracy: ±0.05% rdg. ±1 count
Range Tempco: 70 ppm/°C typ., 125 ppm/°C max.
Calibration Span Adjust Range: 60 to 3800 counts (4 to 20, 10 to 50 mA), 60 to 4000 counts (0 to 20, 0 to 50 mA)
Offset Adjust: ±1999 counts
Slope Change: Reverse input terminal connections

THE MODEL 199D WORKS WITH OMEGA TRANSDUCERS: SEE SECTION B

DIGITAL TRANSDUCER INDICATORS

MODEL 199E VOLTAGE RECEIVER

Features:

- Wide Range Front-Panel Span Selection
- Zero Offset ±1999 Counts
- Floating Input with respect to AC Power Ground Eliminates Ground Loops

SIGNAL MONITOR
INPUT RANGE 0 To 10 V
-88.3
OMEGA ENGINEERING MODEL 199E

199E
$232

- Overvoltage Indication and Protection
- Designed to IEC-348 Class II Safety Standards
- All Screw-Terminal Connections

Transducers Supplied Separately

VOLTAGE INPUT

Interfacing with pressure transducers with high level voltage outputs, the 199E converts signals ranging from 0 to 5 V, 1 to 5 V, 0 to 10 V and −10 to +10 V dc into the engineering units required by your application.

To Order *(Specify model number)*

MODEL	INPUT	PRICE	DESCRIPTION
◆ 199-E1	0-5 V dc	$232 ◆	115 V ac power standard
◆ 199E-E3	0-10 V dc	232 ◆	115 V ac power standard
Other Models			
199E-E2	1-5 V dc	$232	115 V ac power standard
199E-E4	−10 to +10	232	115 V ac power standard
Options			
A	—	$30	Analog Output
D	—	30	BCD Output
Power	—	NC	Specify 5 V dc, 8-28 V dc, 220 V ac

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

SPECIFICATIONS

SIGNAL INPUT

Input Voltage Range: 0 to +5 V dc, +1 to +5 V dc, 0 to +10 V dc, −10 to 10 V dc
Input Impedance (max.): 100 MΩ for 5 V FS, 100 KΩ for 10 V FS
Input Protection: 100 V dc or ac peak
Overvoltage Indication: 20% above FS, Display blanks except for polarity
Normal Mode Rejection Ratio: 65 dB typ. @ 50 or 60 Hz

COMMON MODE

Input Singal to ac Line: ±1400 V dc or ac peak (B Version; ±3000 V dc or ac peak
Common Mode Rejection Ratio: 120 dB

PERFORMANCE

Resolution: 0.05% @ 1999 counts
Accuracy: ±0.05% rdg. ±1 count
Range Tempco: 70 ppm/°C typ., 125 ppm/°C max.
Calibration Span Adjust Range: 60 to 3800 counts (1 to 5 V), 60 to 4000 counts for other ranges
Offset Adjust: ±1999 counts
Slope Change: Via front panel switch and reversing input terminal connections

THE MODEL 199E WORKS WITH OMEGA TRANSDUCERS: ON PAGES B-15 thru B-26

DIGITAL TRANSDUCER INDICATORS

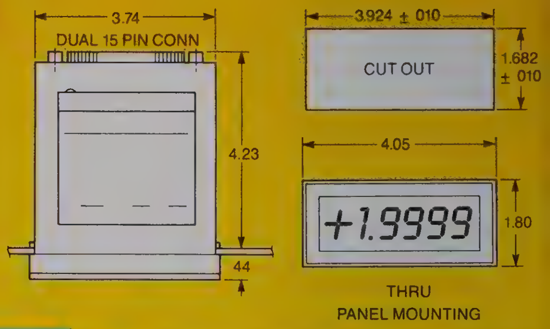
Model DP-350 PRESSURE INDICATOR

Model DP-350
$375
PRESSURE MONITOR
660
psi
OMEGA ENGINEERING
MODEL DP350

For Pressure Transducers, Load Cells and Strain Bridges

- High Impact Plastic Case
- Jumper Selectable Decimal Points
- Scalable Input 20 to 100 mV FS
- Scalable Display FS = 500 to 1999 for 20 to 100 mV Input
- Zero Offset ±6% F.S. (±120 counts)
- 5 or 10 V Excitation
- Optional Dual Set Point

Mounting Dimensions



Note: Cutout is not to DIN dimensions.

Transducers sold separately. See Section B.

To Order *(Specify model number)*

MODEL NO.	PRICE	DESCRIPTION
◆ DP-350 115 V ac	$375	Self contained, panel mount DPM providing bridge excitation and digital readout scalable to most any engineering unit, i.e., weight, pressure, volume, etc. Analog output included. ◆
Other Models		
DP-352 115 V ac	445	Same as above, plus two set points with two 0.5 A relays and analog output. Requires external resistors.
DP-352-KIT	49	Potentiometers and momentary switch for set point utilization.

The DP-350 is a self-contained, panel mount meter providing bridge excitation and digital readout scaled to any engineering unit, i.e., weight, pressure, volume, etc. It provides optional analog setpoints, external tare, autozero, and analog output.

Excellent performance and reliability are obtained by conservative design utilizing the dual slope conversion technique, selection of quality components and extensive burn-in and quality control of all meters.

◆ HIGHLIGHTED MODELS ARE STOCKED ◆

SPECIFICATIONS

Accuracy: ±0.05% of rdg. ±1 count
Linearity: ±0.2% counts typ. ±0.5% counts max.
Temp Co. [−10°C to +60°C]
Full Scale Zero: 0.005% of rdg/°C autozero (without ext. tare pot) ±0.12 counts/°C (with ext. tare pot)
Common Mode Rejection: −80 dB @ dc
Normal Mode Rejection: −45 dB @ 60 Hz
Common Mode Voltage: ±4 volts max.
Bias Current: 1.5 na
Read Rate: 3/sec.
Set Points (optional)
Setability: ±1 count **Hysteresis:** ±10 cour
Temp. Co.: 0.14 counts/°C
Analog Output
Range: 1 V dc = 1000 counts
Accuracy: 0.5% rdg ±1 mV
Load: 2 K ohm min. (1 mA max.)
Bridge Excitation: 10 V dc (+ and −5 V dc) @ 40 mA
Power: 3.5 watts typ., 115/230 V ac ±10%, 47-400 Hz

PROCESS LOOP INDICATOR
Installs anywhere in the loop!

- ± 1999 count full span display
- Powered entirely by signal loop
- 4-20 mA or 10-50 mA ranges
- Field scaling and offset to ±1999 counts
- Dust and oil resistant JIC/NEMA enclosure
- Versatile

81.0
OMEGA
ENGINEERING, INC.
PROCESS INDICATOR
TX-81

To Order:
Specify: Model TX-81 Process Indicator
$229

Rugged Metal Case

In Stock for Fast Delivery

The Model TX-81 Process Loop Indicator is a versatile meter that can be used in any transmitter loop. It provides an easy-to-read liquid crystal display (LCD) from your 4 to 20 mA or 10 to 50 mA transmitter. The JCI/NEMA enclosure provides environmental protection for use in most industrial applications. It can be used in pressure, temperature, humidity or any process variable measurement application where a two wire transmitter is required. No external power is needed. The TX-81 works off your existing current loop power supply and has a voltage drop of only 3.27 volts. The independent adjustments for zero and span over the entire 4000 count range allow one model to be used for most process lab applications. Simply scale the display to match the input range from your transmitter.

Operating Characteristics

ELECTRICAL

Linearity: ±2 counts
Resolution: 500 ppm of full scale
Temperature Range: 0° to 50°C
Span Range: 2000 counts (high reading minus low reading)
Offset Range Low: −200 min. +200 max.
Offset Range Positive: −72 min. +2000 counts max.
Offset Range Negative: −2000 min. +72 counts
Update Rate: 2.2 min., 2.5 typ., 2.7 updates/sec. max.
Voltage Drop 20 mA (4 mA to 20 mA): 3.18 min., 3.22 typ., 3.27 V max.
Equivalent Resistance @ 20 mA (4 mA to 20 mA): 159 min., 161 typ., 164 ohms max.
Voltage Drop 50 mA (10 mA to 50 mA): 3.16 min., 3.20 typ., 3.24 volts max.
Equivalent Resistance @ 50 mA (10 mA to 50 mA): 63 min., 64 typ., 65 ohms max.

PHYSICAL

JIC Enclosure: 16-gage steel construction EGP-I-1967; NEMA Type 13 Neoprene-gasketed cover, Mylar lens overlay
Dimensions:
H: 4¼″ **W:** 7″ (with brackets 7½″)
D: 3 5/16″ **Weight:** 3 lbs.
Display: 0.5″ LCD, 4½ digits
3½ digits of data, + LSD switch programmed zero, °F, °C
Sign reversal switch
Decimal point switches
Overrange indication: MSD, decimal point, and LSD displayed, all others blanked

DIGITAL MULTIMETER

For Fast, Accurate Tests For Voltage, Current, Isolation, Temperature

OMEGA 880 DIGITAL MULTIMETER
88.0
OMEGA 881F DIGITAL MULTIMETER
88.1
DCA
TEMP
ACA
ACV
COM
V-Ω
mA
10A
COM-500V MAX
TYPE K TC

Models 880 and 881 Multimeters

Test Leads Included! Easy-to-use instruments to measure strain gage resistance, insulation resistance, bridge current and output voltages.

SC-800 Carrying Case **$10**

Model 880 **$134**

Model 881F **$209** °F Display

MULTIMETER ACCURACY

	dc Voltage	dc Current	ac Voltage*	ac Current*	Resistance
Sensitivity:	100 μV	1 μA	100 μV	1 μA	100 mΩ
Model 880:	±(.25% rdg ±1 digit)	+(.75% rdg + 1 digit)	±(1% + 3 digits)	±(2% rdg + 2 digits)	±(0.5% rdg + 4 digits)
Model 881:	±(2.5% rdg +1 digit)	±(.75% rdg + 1 digit)	+(1% + 9 digits)	±(2% rdg + 9 digit)	±(0.5% rdg + 4 digits)

**TRMS with Model 881*

TEMPERATURE—MODEL 881

Model	Range	Resolution	Accuracy
881F	0 to +2000°F	1°F	+(5°F + 1 digit) up to 225°F
881C	−20 to +1370°C	1°C	+(3°C + 1 digit) up to 150°C

Notes: ±3 rdg over 225°F (150°C), chart correctable to 1.5% rdg over 600°F (300°C)

Shown smaller than actual size

The OMEGA® Models 880 and 881 are fully portable Digital Multimeters designed with a rugged, high impact case to withstand daily field use. These precision DMM's measure dc voltage and current, ac voltage and current, and resistance. In addition, the Model 881 features TRMS ac voltage and current, and TEMPERATURE MEASUREMENT from a type K thermocouple. Both the Model 880 and 881 feature 0.25% accuracy, and the Model 881 is available with either °C or °F temperature display.

INCLUDED FREE:
Beaded Wire Thermocouple and Connector

How To Order

In Stock for Immediate Delivery

Model	AC	Temperature Range	Price
880	Average Responding	Current and Voltage Only	**$134**
881C	TRMS	−20 to 1370°C	**199**
881F	TRMS	0 to 2000°F	**209**

PRESSURE DISPLAY AND CONTROL SYSTEM

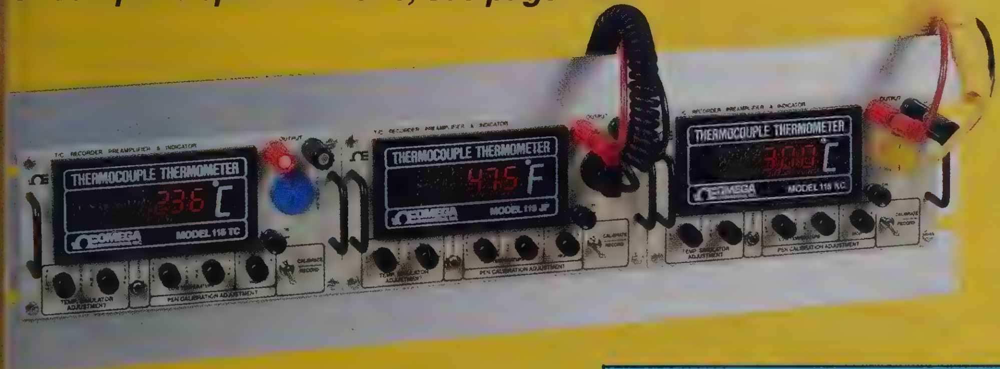
Iodel PC-3500

Built-In 5 or 10 V Excitation Scalable Inputs from 20 to 100 mV FS
Scalable Display FS = 500 to 1999 for 20 to 100 mV Input
Zero Offset ±6% FS, ±120 Counts
Jumper Selectable Decimal Point
Limits, Alarms or Control Functions

PRESSURE MONITOR
881
psi
OMEGA ENGINEERING
MODEL DP350
PC-3500
SELECT
SETPO
1
2
OUT

he Model PC-3500 Digital
ressure Display and Control
ystem is the latest in readout,
ontrol, limits and/or alarms that is
esigned specifically for use with
ressure transducers. Just connect
ne pressure transducer for display,
r set in limits for simple control
unctions. Operates in minutes!

or complete specifications, see page D-9.


THERMOCOUPLE THERMOMETER
236 C
OMEGA
MODEL 115 TC
THERMOCOUPLE THERMOMETER
475 F
OMEGA
MODEL 115 JF
THERMOCOUPLE THERMOMETER
300 C
OMEGA
MODEL 115 KC

From
$550

'9" Rack Panel
'or 1, 2 or 3 PC-3500's
'onsult Sales for Details

)rder on Right
)ne, Two or Three Channel
'anel Models For Pressure
Temperature Version Shown—
Iodel R15000. See the OMEGA
emperature Measurement Handbook
ection N for details.)

To Order *(Specify model number)*

MODEL	PRICE	DESCRIPTION
PC 3500-P1	$ 550	One Channel 19″ Rack Model
PC 3500-P2	1050	Two Channel 19″ Rack Model
PC 3500-P3	1550	Three Channel 19″ Rack Model

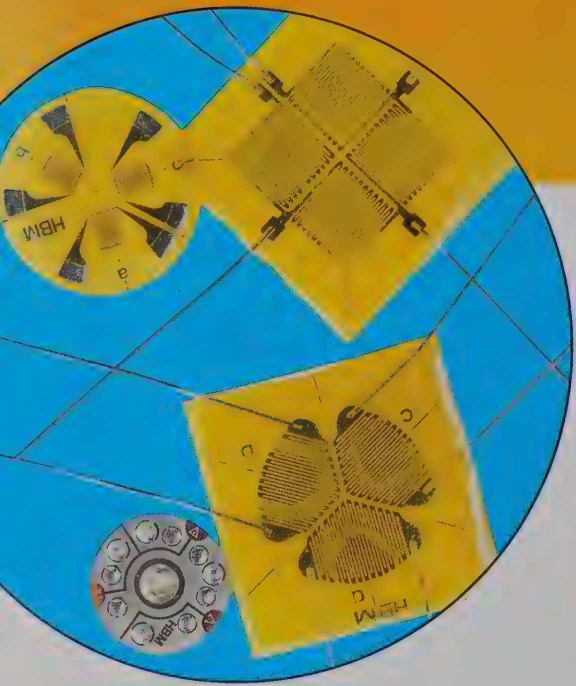
PROCESS CONTROLLERS

CN-25 Series for Pressure

- Precision ON/OFF Control
- Single and Dual Set Points
- Reliable Digital Design
- Easy to Change Ranges
- Scalable Displays to Engineering Units

CURRENT LOOP
CN-25D
$381
PR
OUT 1
OUT 2

Transducers Sold Separately
See Section B



Complete Strain
Gage Selection
See Section E

SELECTED MODELS—FOR COMPLETE INFORMATION, SEE THE OMEGA TEMPERATURE MEASUREMENT HANDBOOK AND ENCYCLOPEDIA™

To Order *(Specify model number)*

	Sensor Output	1 Set Point	Price	
	Strain Gage 0.6 to 30 mV/V	CN 25J-RX MI	$477	
➧	Frequency to 10 kHz	CN 25C-FI MI	415	➧
➧	Current 4 to 20 mA	CN 25D-I2 MI	381	➧
➧	Voltage to 10 V dc	CN 25-E-E3 MI	381	➧
		Dual Setpoint		
	Strain Gage 0.6 to 30 mV/V	CN 25J-RR-MI SI	503	
➧	Frequency to 10 kHz	CN 25C-FI-MI SI	431	➧
➧	Current 4 to 20 mA	CN 25D-I2-MI SI	407	➧
➧	Voltage to 10 V dc	CN 25-E-E3-MI SI	407	➧

➧ HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY ➧

FOR COMPLETE INPUT SPECIFICATIONS,
SEE PAGES FOR THE 199J, 199C, 199D, and 199E DIGITAL PANEL METERS IN THIS SECTION

OLLER
0
MODE
MEGA
PROCESS CONTROLLER
+1974
OUT 1
OUT 2
RESET
MODE
OMEGA
PROCESS CONTROLLER
+1998
OUT 1
OUT 2
RESET
MODE
OM

dc VOLTAGE
CN-25E
$381

SELECTABLE FREQUENCY OUTPUT TRANSDUCERS
CN-25
$415

Pressure/Strain

The CN-25 controllers for rate and pressure control accept input from a variety of transducers, including magnetic pickups, ac tachometers, photocells, and pressure and strain gage transducers. Available with either ON/OFF or relay output, the CN-25C and CN-25J are ideal in rate or pressure control applications.

CN-25J (Strain Gage)

- **10 V Excitation Voltage**
- **Rate/Flow and Pressure/Strain Gage**
- **0.6 to 30 mV/V Input from Strain Gages**

CN-25C (Rate)

- **Pulse or Sine Input Over Wide Range of Amplitudes**
- **Isolated Input (to analog ground) in Extreme Conditions**
- **Automatic Threshold and Hysteresis Adjustment**

Voltage/Current

The current loop and dc Voltage models of the CN-25 Series are easy to use, versatile controllers, able to accept inputs from a variety of pressure and force transducers with voltage or current outputs. They can be used to control pressure, flow, or displacement, with a display of output data in user desired units.

- **Designed to IEC-348-Class II**
- **Floating Input to Eliminate Ground Loops**
- **Wide Selection of Span, Offset and Slope**
- **Overrange Indication and Protection**
- **Easy to Change Input Ranges**

CN-25E (Voltage)

CN-25D (Current)

Dimensions:

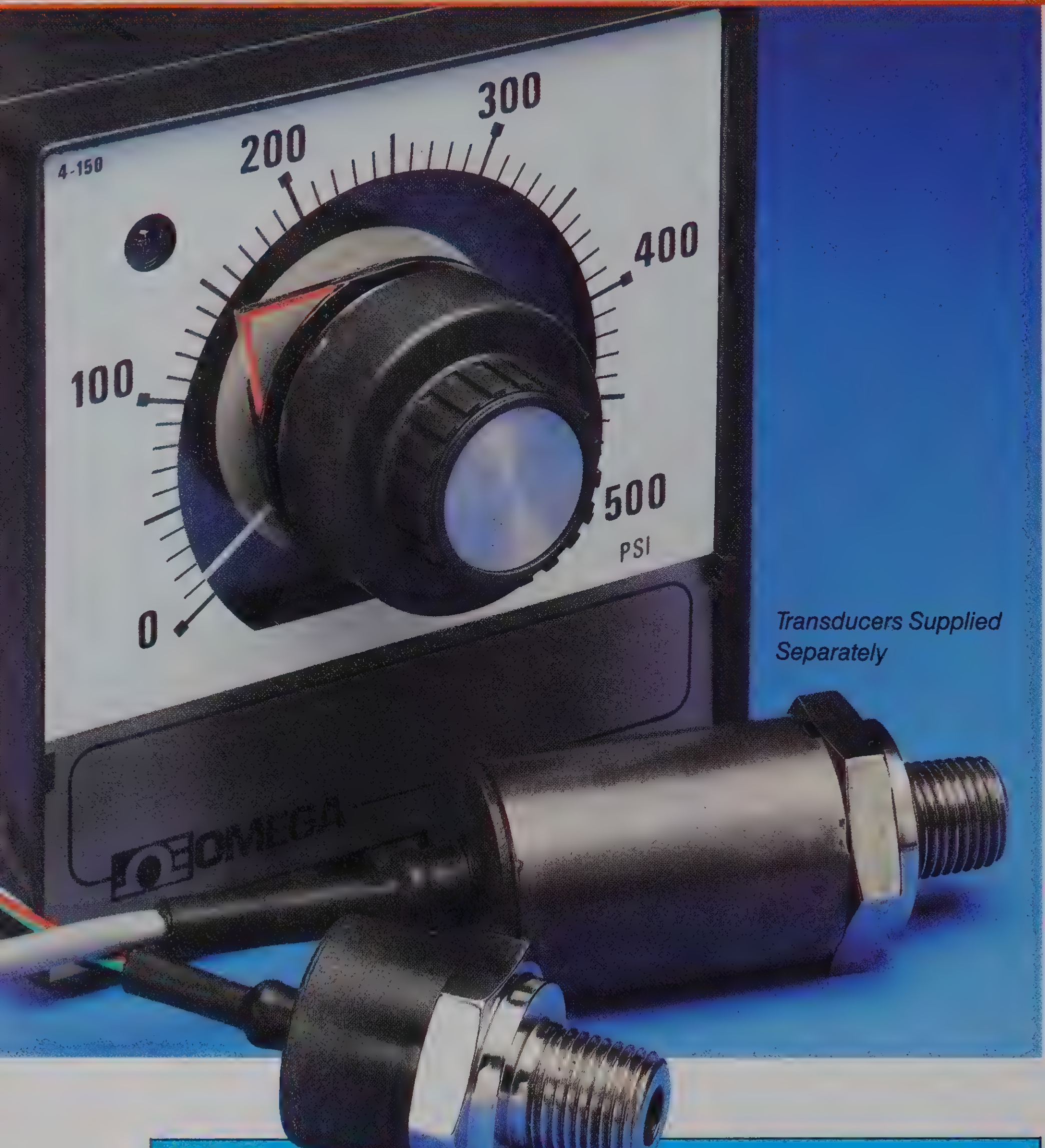
Panel Cutout: 3.622″ (92 mm) square
Bezel Dimensions: 4.10″ (104.1 mm) square
Depth Behind Bezel: 6.97″ (170.8 mm)

SPECIFICATIONS

GENERAL:

Display: 0.56″ (14.2 mm) LED, 3½ digits, polarity, overrange indication
Analog to Digital Conversion: Dual slope, 3 phase conversion with automatic zero correction; complete conversion each cycle; 2.5 conversion/sec.
Line Voltage: 110 or 220 V ac
Consumption: Less than 4 watts typical
Operating Ambient: 14 to 122°F (−10 to 50°C)
Storage Ambient: −40 to 185°F (−40 to 85°C)
Relative Humidity: 0 to 90%, noncondensing

ANALOG PRESSURE CONTROLLER



Transducers Supplied Separately

Models I921 and I922

- **Accurate Control**
- **Compact Design**
- **Single and Dual Set Points**
- **High Impact Plastic Case**

The **OMEGA I921 AND I922 Controllers** combine solid state accuracy with low cost. The I921 has a single set point and the I922 has two. They feature an easy-to-read dial with a full 250° (angular) indicating meter and time proportional control adjustable to true ON/OFF. Standard features on the I921 and I922 models include a plug-in 10 amp relay, isolated wiring chamber, either 115 or 230 V ac operation (field convertible) and push-to-engage set point. The I922 additionally features either a tracking (standard) or non-tracking second set point.

Model I921

$250

To Order

(Specify model number)

Input dc	Single Set Point $250	Dual Set Point $295	Range PSI
0-100 mV	I921P-C60	I922P-C60	60
	I921P-C100	I922P-C100	100
	I921P-C500	I922P-C500	500
0-5 V	I921P-A60	I922P-A60	60
	I921P-A100	I922P-A100	100
	I921P-A500	I922P-A500	500
0.5-5.5 V	I921P-B60	I922P-B60	60
	I921P-B100	I922P-B100	100
	I921P-B500	I922P-B500	500
1-6 V	I921P-D60	I922P-D60	60
	I921P-D100	I922P-D100	100
	I921P-D500	I922P-D500	500

▸ HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY ◂

Specifications

Panel Cutout: 3⅝″ (92 mm) sq. per DIN-43700. Depth behind panel 3⅞″ (98 mm)

MODES/SIGNAL FORMS

Time Proportioning to On/Off :

- Cycle time: adjustable approximately 2-36 sec.
- Bandwidth: adjustable 0-10% of span with set point in center
- Manual Reset: adjustable ±12% of span
- Field convertible to on-off mode with differential approximately .25% of span, symmetrical around set point

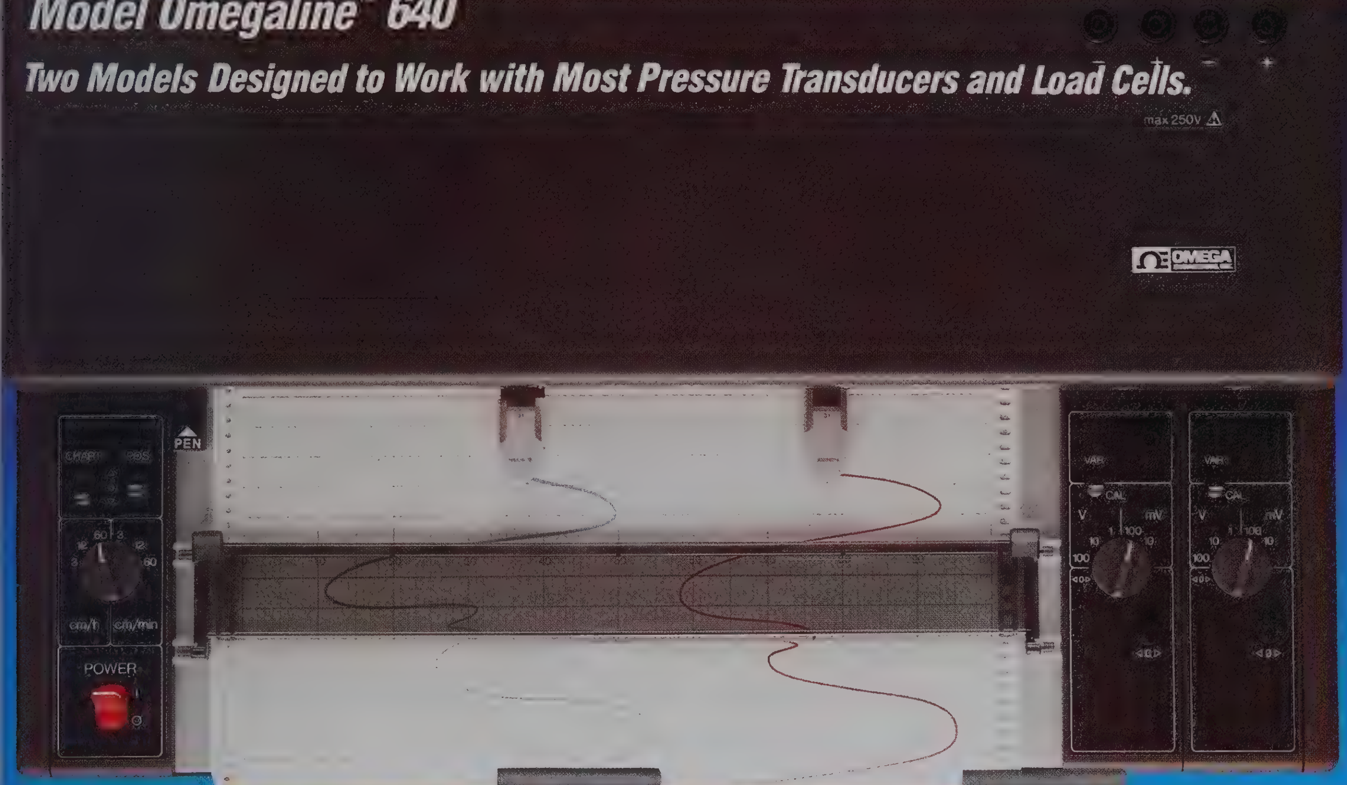
SWITCHING DEVICES

10 amp Mechanical Relay:

- Plug-in for easy replacement
- Rated 10 amp @ 115 V ac resistive; 5 amp at 240 V ac resistive. SPDT.

Model Omegaline™ 640

Two Models Designed to Work with Most Pressure Transducers and Load Cells.



$950
1 Channel with CV Module

VAR
CAL
x100%
max 250 V

MODULE V
- 17 mV & V Ranges
- Up to 200% Zero Offset in Steps

MODULE CV
- 20 Current & Voltage Ranges
- AC/DC Ranges

STATE-OF-THE-ART FEATURES
- Direct temperature readout
- Quartz-controlled 6-speed chart drive, 3, 12, 60 cm/hr, cm/min

QUALITY
- Backed by 20 years of OMEGA ENGINEERING experience
- Rugged, scratch-resistant case
- Fully enclosed front cover to keep dust out and quality in
- Tilt stand carrying handle

VALUE
- Precision instrumentation at an economical price
- Easy-to-replace disposable pens
- Z-fold or roll paper
- 250 mm recording width

To Order *(Specify model number)*

1 Channel	Price
▶ Model 640-1-V	$ 960 ◀
▶ Model 640-1-CV	$ 950 ◀
2 Channel	
Model 640-2-V	$1390
Model 640-2-CV	$1380

▶ **HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY** ◀

Extra Paper: Order **SL-RP-1** $8

STRIP CHART RECORDERS

For Pressure Measurement

Model 555

To Order

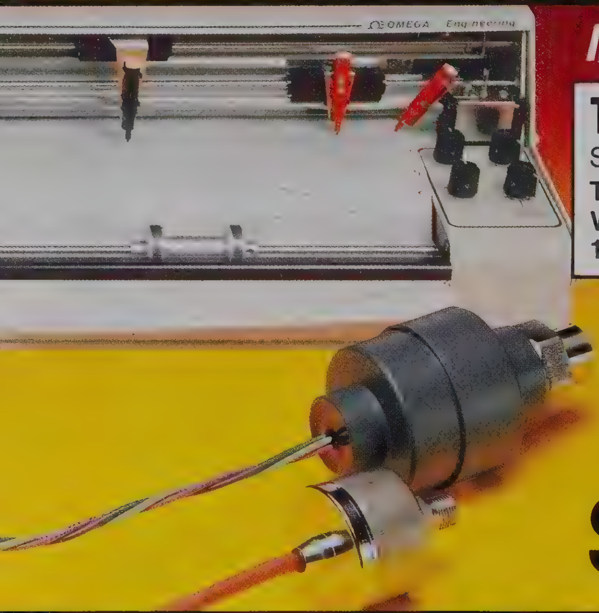
Model 555 Single Pen Recorder
$895 (not shown)

585 Dual Channel	$1,295
595 Three Channel (shown)	$1,850

$895

The Model 555 one pen, **Model 585** two pen and **Model 595** three pen recorders are the newest and most dramatic in the line of intelligently priced recorders. Every possible feature has been included in these versatile recorders to provide the user with optimum flexibility, accuracy, and long-term reliability.

- **2 Pen Recorder**
- **1 mV to 50 Volts Variable Attenuator**
- **0.5 Second Per Response**
- **Crystal Controlled Stepper Chart Drive**
- **Pulse Modulated Servo System**
- **Flat Bed Recorder**
- **Paper and Pens Included**



Model 0-5217-5M

To Order

Specify **Model 0-5217-5M $1,525**
Two Channel 250 mm Chart Width Five Millivolt Ranges: 1, 10, 100 mV, 1, 10 V

Model 0-5217-5M
$1,525

Precision Design

- **Web Feed Chart Drive — Accurate, Reliable, Self-Aligning. A Time Tested Adaptation of Precision Paper Feeds**
- **Simple Chart Loading**
- **Sprocketless Paper — The Web Feed Also Allows Use of Sprocketless Paper. Gives a Fileable, Standard Size Record without Annoying or Expensive Sprocket Holes.**
- **Integral Tear Bar**
- **Zero Offset — 10% to 110%**
- **Paper and Pens Included**

Model 143

To Order

Model 145 $595
Millivolt and milliamp inputs manually selectable

$595

143 Recording Module

- **For Custom Applications**
- **Multi Speed**
- **Multi Input Spans**
- **100 mm Chart Width**
- **Paper and Pens Included**

The Model 143 is a single channel recorder designed as a bench top or panel mounting recording module. All essential elements to assure precise and reliable charting are compactly mounted in a lightweight main frame which also serves as the enclosure.

PRESSURE RECORDERS
4″ and 8″ Models

Series CT-614

- **Compact: 5¼″ × 5¼″ × 2¼″**
- **Lightweight: 2 lbs.**
- **Accurate and Reliable**
- **1 Day or 7 Day Chart Drive**
- **Rugged: All-steel Case with Baked, Hammerloid Enamel Finish**
- **0-100 psi**

The 4-inch Chart packs 7-day pressure recording capability into a compact, stem-mounted case. If you've been relying on a simple pressure gage for spot pressure readings, you will find it more convenient to use a chart with a permanent chart record of pressure trends and fluctuations.

The 8-inch Chart provides more chart detail, yet the instrument's 9½″ × 9½″ x 3½″ case is still remarkably compact and light weight. The pressure measuring elements are heat treated to prevent hysteresis-related inaccuracies. The dial assembly is mounted in a strong, all-metal case, and the door is sealed against a rubber gasket by a specially designed spring latch. Besides their small size, the chart instruments are lightweight—easily installed with little mechanical preparation.

RECORD PRESSURE 24 HOURS A DAY!

OMEGA
MONDAY
TUESDAY
NITE
6 AM
6 PM

$225
CT 614-1007

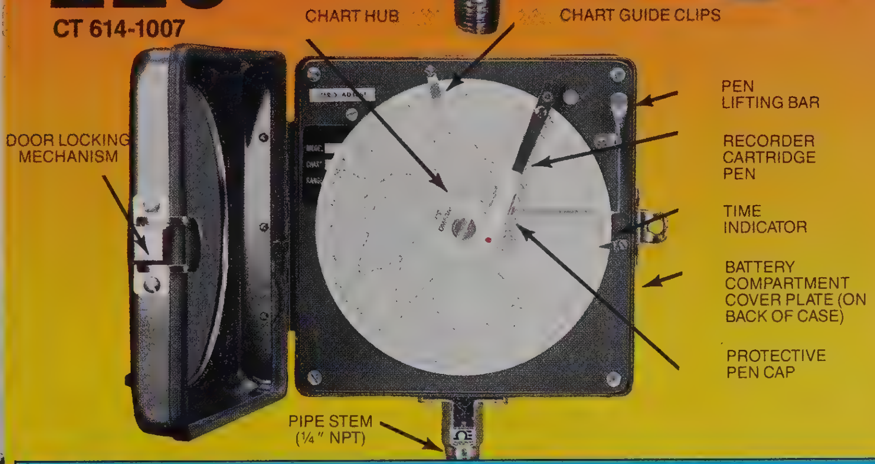


CHART HUB
CHART GUIDE CLIPS
PEN LIFTING BAR
DOOR LOCKING MECHANISM
RECORDER CARTRIDGE PEN
TIME INDICATOR
BATTERY COMPARTMENT COVER PLATE (ON BACK OF CASE)
PROTECTIVE PEN CAP
PIPE STEM (¼″ NPT)

To Order *(Specify model number)*

CHART SIZE	PRESSURE	MODEL NUMBER	PRICE
4″	▶ 0-100 PSIG	CT 614-100 7 day	**$225** ◀
	0-100 PSIG	CT 614-100 1 day	225
8″	▶ 0-100 PSIG	CT 618-100 7 day	325 ◀
	0-100 PSIG	CT 618-100 1 day	325

Replacement Batteries: MN-1500-2 two alkaline batteries included
Replacement Charts: 0-100 grid 4″ CT-414-100F-[1 or 7 day] **$7**
0-100 grid 8″ CT-418-100F-[1 or 7 day] **$9**

Standard Models are stem or wall mounted with battery powered chart drive, and are supplied with a box of 100 charts, batteries and pens.

▶ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◀

DATA LOGGER

05 0073
POWER
OMEGA
205
7 8 9
4 5 6
1 2 3
0

Transducers Supplied Separately

To Order *(Specify model number)*

MODEL NO.	CHANNELS	PRICE
*4-20 mA Current Loop Input**		
◆ OM-205-I1 M4	12	**$2900** ◆
OM-205-I1 M4 × 2	24	3425
OM-205-I1 M4 × 3	36	3950
*0-10 V Voltage Input**		
◆ OM-205-V51 M5	12	**$2900** ◆
OM-205-V51 M5 × 2	24	3425
OM-205-V51 M5 × 3	36	3950
*0-100 mV Voltage Input**		
◆ OM-205-V52 M5	12	**$2900** ◆
OM-205-V52 M5 × 2	24	3425
OM-205-V52 M5 × 3	36	3950

**Input current and voltage are field adjustable.
All units are factory set for 0% to 100% display and printout.
Printout units, span and offset are field adjustable or can be factory adjusted to order.
Contact Sales Department for details.
For complete details on mixed inputs, programmable alarms, and computer interfaces, see the OMEGA Temperature Measurement Handbook and Encyclopedia™.*

◆ ***HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY*** ◆

Model OM-205

- **Up to 36 Channels**
- **9 Programmable Alarms**
- **Mixed Inputs (3 Groups)**
- **Programmable Logging Schedule**

**H: 5.5″ (139 mm)
W: 10.5″ (266 mm)
D: 16″ (406 mm)
Only 18 to 22 pounds (8.1-9.9 kg)**

Easy Programming

Ten function keys and ten numeric keys do it all. Simple, color-coded touch pad permits operator to set logging schedule, read values on demand, set and assign alarms, and perform all operations. For system security, internal switch can inhibit unauthorized use of touch pad.

Versatile

Controls visual and audible alarms when alarm I/O and ARP options are chosen.

Documentation

Programmable. Printing instructions are under operator control. Prints selected channel readings when scheduled, and any alarm status change regardless of when it occurs. Records channel values as well as day, time, and exceeded limit.

Shows:

- **Temperature**
- **Alarm**
- **Time**
- **Date**

12 Channels
$2,900

---

24 Channels
$3,425

---

36 Channels
$3,950

DATA LOGGER

odel OM-271 atures

- Microprocessor Controlled
- 32 Channel Trend Recording
- Thermocouple Input— J, K, T, E, R, S and N
- Automatic Self-calibration
- Operator Selectable Ranges
- Real Time Clock
- Alarms—High and Low on Each Channel
- Continuous Serial ASCII Data Output
- Thermal Printing

M-271 Includes:

- Data Log Mode
- Millivolt & Volt Scales for Transducers
- Thermocouple Conditioning
- 100Ω Platinum RTDs $\alpha = .00385$ and .003923
- Δ T Mode
- Alarm Mode Chart and Print Rates
- Keyboard Lockout Password
- Remote ASCII Programming
- °F or °C Readout

Order:
Model OM-271
$4,100

R COMPLETE DETAILS, E THE OMEGA TEMPERATURE EASUREMENT HANDBOOK d ENCYCLOPEDIA™.

0
10
20
30
40
50
60
70
80
90
OPERATE
STANDBY
AUTO
OMEGA
ENGINEERING, INC.

Remote Programming Standard!

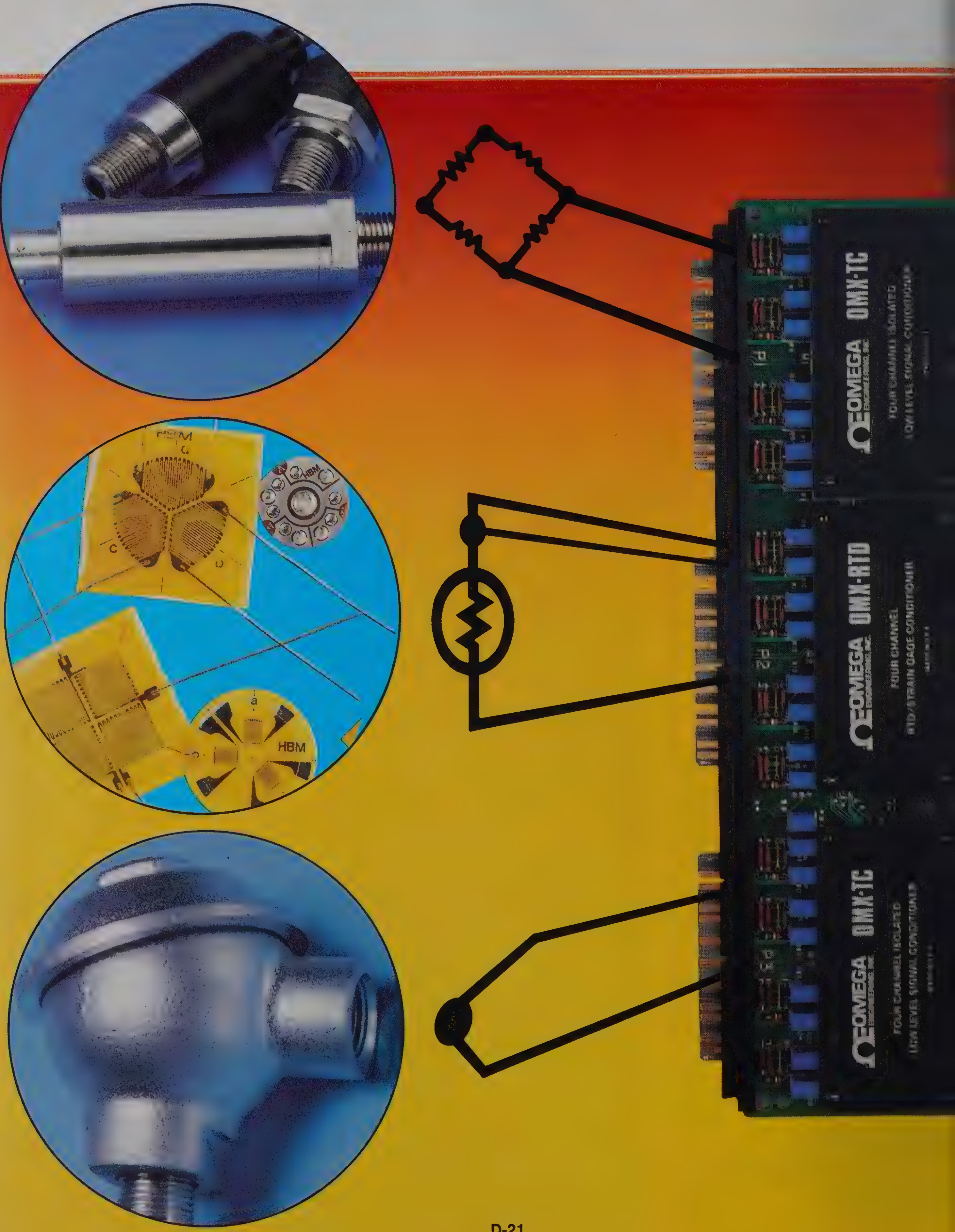
Transducers Supplied Separately

Trend or Data Display

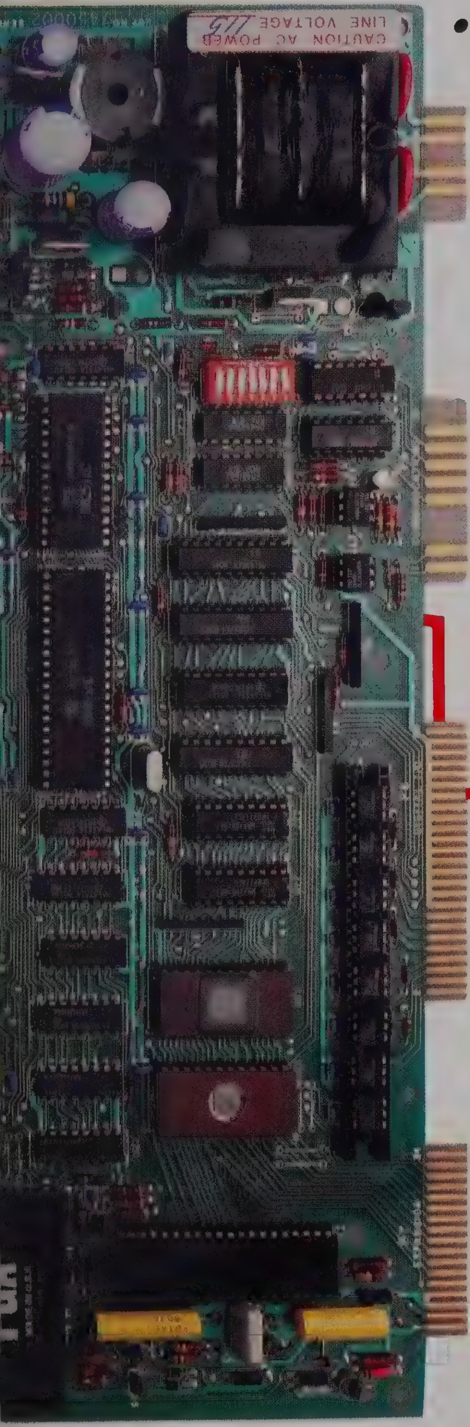
Both models record the trend of every selected channel in under 2 second cycles. In addition, the Model OM-271 can be converted into a data logger either from the keyboard or remotely. In this mode, the input signals are digitized and printed in a five column format across the chart. A printout of all 32 channels takes approximately 60 seconds and includes the date and time. Print frequency can be programmed from once each minute to once every 5000 minutes.

All 32 channels are scanned every 2 seconds and compared to the stored alarm values. When an alarm is detected, either the high or low alarm relay is immediately activated. During every scan cycle, the internal reference source is used to check both zero and full scale values and make calibration adjustments automatically if needed.

COMPUTER INTERFACE SYSTEM


HBM
HBM
HBM
P1
P2
P3
OMEGA ENGINEERING, INC.
OMX-TC
FOUR CHANNEL ISOLATED
LOW LEVEL SIGNAL CONDITIONER
OMEGA ENGINEERING, INC.
OMX-RTD
FOUR CHANNEL
RTD/STRAIN GAGE CONDITIONER
OMEGA ENGINEERING, INC.
OMX-TC
FOUR CHANNEL ISOLATED
LOW LEVEL SIGNAL CONDITIONER

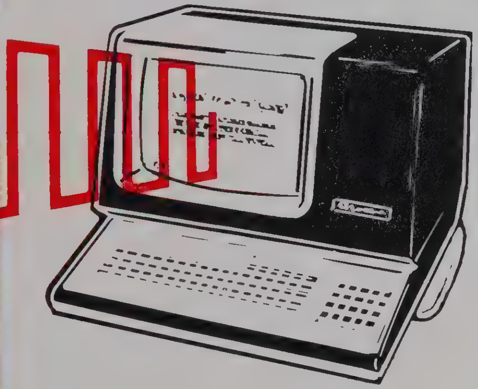
μMEGA ™ 4000 Single-Board Measurement and Control System



• Intelligent, Expandable, Direct Data Acquisition from Process to Computer.

At Last . . . A complete measurement and control system designed on a single board. It's μMEGA. The first low-cost, easy-to-use, easy-to-implement system optimized for pressure, strain, temperature and low-level single measurements.

μMEGA SYSTEMS directly interface to industrial transducers, process their signals, and transmit usable data to your computer or terminal, easily and cost effectively.



EASY INTERFACE

- **Serial Data Link**
- **Powerful Command Set**
- **Linearized Data in Engineering Units**
- **Digital I/O For Control**

VERSATILE INPUT

- **Plug-In Conditioning Modules**
- **Input Function Switch Programmed**
- **Mixed Inputs in Groups of 4**
- **Thermocouples, RTD's and Low-Level Signals**

EXPANDABLE SYSTEMS

- **On Site Expansion**
- **Main Board Up to 12 Channels**
- **Expander Board Adds 12 Channels**
- **Multi-Clusters Up to 384 Channels Per Communications Bus**

COST EFFECTIVE!

$1,897

12 CHANNEL LOW LEVEL SYSTEM

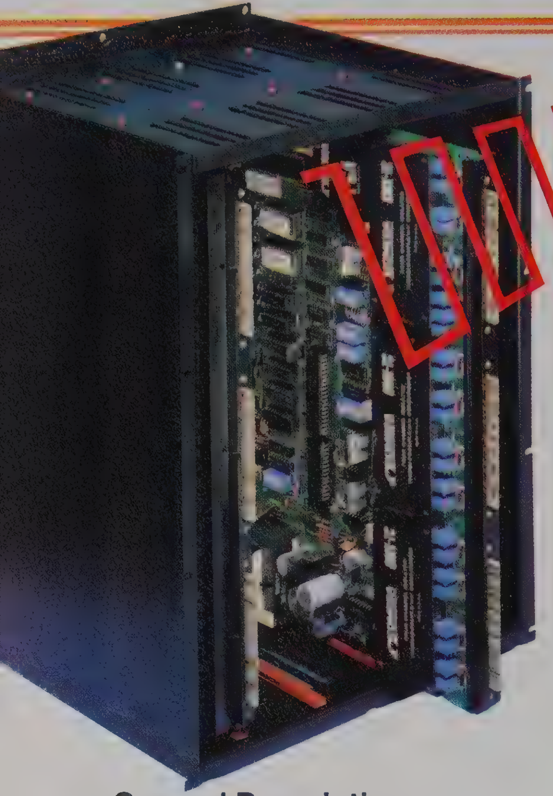
μMEGA-4000 *with OMX-RTD Modules for 30 and 100 mV output transducers.*

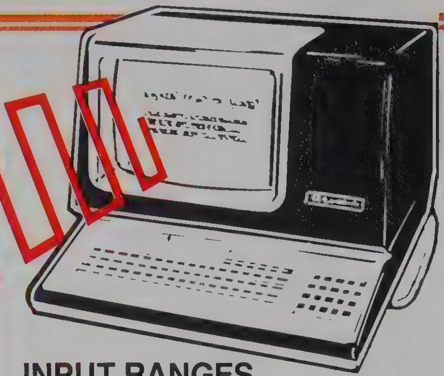
$2,167

12 CHANNEL ISOLATED SYSTEM

μMEGA-4000 *with OMX-TC Modules for transducers with 25-100 mV outputs.*

μMEGA™ SYSTEMS
INTERFACE TO ANY COMPUTER WITH AN RS—232 PORT AND SERIAL ASCII





General Description

The μMEGA-4000 is a complete, microcomputer based Measurement and Control System on a single board. It is designed to provide a low cost solution to processing analog input data and digital input/output controls. The μMEGA-4000 provides sensor signal conditioning, analog multiplexing, analog to digital conversion, digital I/O and serial communications, all on one printed circuit board.

A unique plug-in module approach allows the selection of standard signal conditioning modules for direct connection to a wide range of sensors. A single μMEGA-4000 board will accept 4, 8, or 12 analog input channels with expandability to 48 channels in a 4 board (cluster) configuration with the addition of three μMEGA-4010 Expander Boards and up to 384 channels in a multi-cluster configuration. Each board also offers interface to 8 digital inputs and 8 digital outputs.

The on-board microcomputer scales, linearizes and converts the input data to engineering units and stores the results in random access memory. The data stored in memory are continuously updated at a minimum rate of 15 or 30 readings/second.

INPUT RANGES

OMX-TC Module

LOW LEVEL VOLTAGE INPUT

SPAN	ACCURACY
± 25 mV	± 0.08% SPAN
± 50 mV	± 0.05% SPAN
± 100 mV	± 0.05% SPAN

THERMOCOUPLE INPUT

Type	Range	Accuracy
J	− 100°C to + 760°C − 148° F to + 1400° F	± 1.0°C ± 1.8° F
K	− 100°C to + 1232°C − 148° F to + 2250° F	± 1.1°C ± 2.0° F
T	− 200°C to + 400°C − 328° F to + 750° F	± 1.0°C ± 1.8° F
S	+ 300°C to + 1768°C + 572° F to + 3214° F	± 3.2°C ± 5.8° F
CMV Channel to Channel or Channel to Ground		± 1000 V Peak, Continuous
Maximum Differential Voltage		± 130 V rms

OMX-RTD Module

STRAIN GAGE INPUT

Range	Span	Accuracy (% Span)
± 30 mV	60 mV	± 0.015
± 100 mV	200 mV	± 0.01

Excitation Voltage User Supplied

100Ω PLATINUM RTD INPUT

Type	Range	Accuracy
α = 0.00385 or 0.00392	− 200°C to + 185°C − 328° F to + 365° F	± 0.3°C ± 0.6° F
	− 200°C to + 700°C* − 328° F to + 1292° F*	± 0.5°C ± 0.9° F

*Requires Recalibration

SOLID STATE SENSOR INPUT

AD590	− 55°C to + 150°C − 67° F to + 302° F	± 0.2°C ± 0.4°F
Sensor Excitation Voltage	+ 4.75 V to + 30.0 V (User Supplied)	
CMV Channel to Channel		± 7.0 V
Maximum Differential Voltage (without damage)		± 130 V rms

TYPICAL 12 CHANNEL SYSTEM

With Strain Gage Inputs in a Card Cage with all Connectors.

1. List Configured Boards*	
1 ea. μMEGA 4000-1-RTD-RTD-RTD	**$1,884**
2. Excitation Supply	
1 ea. R10T 240	**135**
3. Add Enclosure	
1 ea. OMX-1810 (Single Board)	**98**
4. Select Connectors	
1 ea. OMX-1802A (Power)	**15**
1 ea. OMX-1803 (Communications)	**7**
1 ea. OMX-1804 (Digital I/O)	**15**
Total	**$2154**

**Analog Input Connectors are included with Configured Boards*

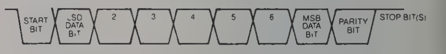
TYPICAL 48 CHANNEL SYSTEM

With Millivolt Inputs in a Card Cage with all Connectors.

1. List Configured Boards*	
1 ea. μMEGA 4000-1-TC-TC-TC	**$2,154**
3 ea. μMEGA 4000-1-TC-TC-TC	**5,562**
2. Add Enclosure	
1 ea. OMX-1811 (Card Cage)	**249**
4. Select Connectors*	
1 ea. OMX-1802A (Power)	**15**
1 ea. OMX-1803 (Communications)	**7**
4 ea. OMX-1804 (Digital I/O)	**60**
Total	**$8,047**

**Analog Input Connectors are included with Configured Boards*

ASCII Character



The μMEGA System works with any computer having a RS-232C or 20 mA ASCII port. OMX range modules may be used in any combination. Actual range for a 4 channel module is selected by DIP switches on the μMEGA Board.

For Complete Details, See The OMEGA TEMPERATURE MEASUREMENT HANDBOOK AND ENCYCLOPEDIA™ or the OMEGA COMPUTER INTERFACE HANDBOOK.

COMPUTER INTERFACE SYSTEM

WB-31 ANALOG TO RS-232 INTERFACE

WB-31
WHITE BOX
OMEGA ENGINEERING INC.
ANALOG/RS-232C INTERFACE
OMEGA
TAC-386

Hook-up Cables Optional

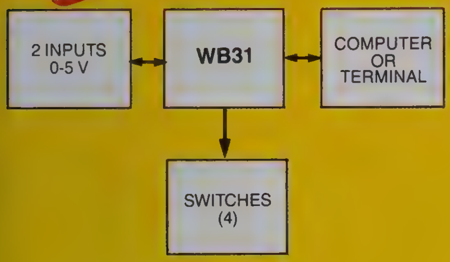
TAC-386 Sold Separately $125

WB-31
$395
2 Channels

Probes Sold Separately

NEW! 8 CHANNEL MODEL

WB-38
$595



Features:

- **2 or 8 Inputs, ±5 V**
- **4 TTL Outputs to Control Switches, Sound Alarms, etc.**
- **Compatible with Most Computers or Terminals with a Serial Port**
- **Can be Accessed by Most High Level Languages such as BASIC, FORTRAN, etc.**

- **Links Process Measurement with Your Computer**
- **Easy-To-Use Interface**
- **Low Cost**

The OMEGA® WB-31 WHITE BOX™ allows you to use your computer to measure temperature, log data, etc. on two or 8 analog inputs. Just connect an analog process signal to one of the inputs and plug the WB-31 into your computer. Simple commands tell the WB-31 what is to be done, for example sending it the letter "R" would give you a reading of the current input channel. The digital outputs add control capabilities. The four outputs allow your computer to trigger switches, sound alarms, work heaters, etc., all through solid state switching devices.

SPECIFICATIONS

Power: 110 V ac or 220 V ac, internally selectable, 50/60 Hz.
Size: 8.5 in. × 5.5 in. ×1.75 in.
Weight: 4 lbs.
Connections: Serial I/O connector is standard 25 pin female SUB-D. Connections to analog inputs and TTL outputs are made via terminal blocks.
Analog inputs: 0 to ±4.999 volts, 12 bits plus sign A/D, 1.25 mV resolution.
Outputs: 4 single bit 40 mA open collector outputs.
Communications: RS-232C or 20 mA current loop with various baud rates and word structures selectable by internal switches.
Conversion Speed: 7.5 per second (133 ms).

SIGNAL CONDITIONING SYSTEM
FOR PRESSURE AND STRAIN

OM-3 Series

OM3
OMEGA
MODULES
OMX-1300
POWER SUPPLY
OMX-1302
POWER SUPPLY
POWER SUPPLY
BACKPLANE
& ADAPTOR

= A COMPLETE SIGNAL CONDITIONING SYSTEM

CONDITIONING MODULES

OMEGA® OM-3 signal conditioning modules accept transducer outputs and provide a 0 to 10 volt and a simultaneous 4-20 mA output for process loop control and alarm functions.

Current Input

Nonisolated Modules **$135**
Common Mode Voltage ± 6.5 V

Model No.	Input Range
OM3-I-4/20	4-20 mA
OM3-I-0/20	0-20 mA

Isolated Modules **$175**
Common Mode Voltage ± 1500 V pk max

Model No.	Input Range
OM3-II-4/20	4-20 mA
OM3-II-0/20	0-20 mA

SEE THE OMEGA® TEMPERATURE MEASUREMENT HANDBOOK AND ENCYCLOPEDIA™ FOR COMPLETE SPECIFICATIONS. SEE SECTION R.

Strain Gage Input

Model OM3-S-3
The strain gage module provides a bridge excitation voltage of + 10 V and can be used with a bridge resistance of 300 Ω or greater.

Millivolt and Voltage Input

Nonisolated Modules **$135**
Common Mode Voltage ± 6.5 V

Model No.	Input Range
OM3-mV-10	± 10 mV
OM3-mV-50	± 50 mV
OM3-mV-100	± 100 mV
OM3-V-1	± 1 V
OM3-V-5	± 5 V
OM3-V-10	± 10 V

Isolated Modules **mV $200**
Common Mode **V 175**
Voltage ± 1500 V

Model No.	Input Range
OM3-ImV-10	± 10 mV
OM3-ImV-50	± 50 mV
OM3-ImV-100	± 100 mV
OM3-IV-1	± 1 V
OM3-IV-5	± 5 V
OM3-IV-10	± 10 V

POWER SUPPLIES

Module OMX-1300 **$99**
Input Voltage: 105 to 125 V ac, 50 to 400 Hz
Output Voltage: ±15 V
Output Current: ±200 mA

Model OMX-1302 **$106**
Input Voltage: 22.3 V to 26.4 V
Output Voltage: ±15 V
Output Current: ±190 mA

BACKPLANES

- **4, 8, or 16 Channels**
- **Accepts all OM3 Modules**
- **Connectors Included**

OM3-BP-16
16 Position **$345**

OM3-BP-8
8 Position **240**

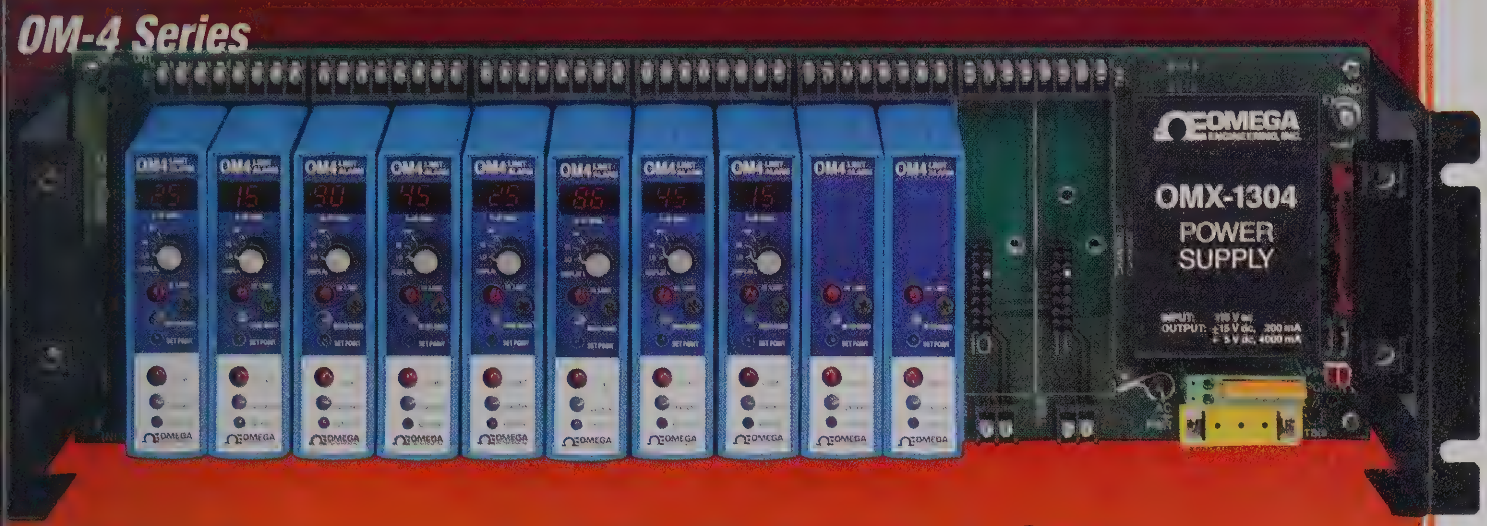
OM3-BP-4
4 Position **120**

19″ Rack Mount Adaptor Kit
- **Accepts OM3 Backplanes**

OMX-1330 .... **$30**

THERMOCOUPLE AND RTD VERSIONS ALSO AVAILABLE. SEE SECTION R.

ALARM AND CONTROL SYSTEM
HREE STEPS TO A SYSTEM



1. Order Modules

Dual Set Point Alarm Modules with 3 Digit LCD Readout

Model	Description	Price
OM4-DA-V	0 to 10, ± 10 V dc Input	$160
OM4-DA-0I	0-20 mA Input	160
OM4-DA-4I	4-20 mA Input	160

Dual Set Point Nonindicating Alarm Modules

Model	Description	Price
OM4-A-V	0 to 10, ± 10 V dc Input	$110
OM4-A-0I	0-20 mA Input	110
OM4-A-4I	4-20 mA Input	110

2. Order Backplane and Power Supply

Backplanes

Model	Description	Price
OM4-BP-4	4 Position Backplane	$150
OM4-BP-12	12 Position Backplane	$345

19″ Rack Adaptor for OM4 Backplanes

Model	Price
OMX 1334	$30

Power Supply 115 VAC

Model	Price
OMX-1304	$175

Output ± 15 V @ 200 mA
+ 5 V @ 4000 mA

Power Supplies

Model	Price
OMX-1303	$125

Output ± 15 V @ 150 mA
+ 5 V @ 1000 mA

OM4 Design Features:

The OM4 Series Alarm Limit Subsystem is designed to provide an easy and convenient solution to alarm/annunciation problems in measurement and control applications.

The OM4 modules have five user programmable jumper options. Each unit can be configured for unipolar or bipolar inputs, both set points can be configured for HI or LO limit operation, and both relays can be configured for Normally Open (NO) or Normally Closed (NC) operation. These options allow the user to readily tailor the OM4 units to his specific needs.

3. Order Accessories

Accessories

Model	Description	Price
OMX-1344	Package of 20 Spare Programming Jumpers	$2

OMX-1312
OMX-1324

Model	Description	Price
OMX-1312	26 Pin Female Ribbon Connector	$10
OMX-1317	26 Pin Male Board Mounting Connector	10
OMX-1324	26 Pin Female Connector to Screw Terminals	40
OMX-1315	2′ Cable with 2 Connectors	19
OMX-1354	3′ Cable with 1 Connector	19

OMEGA® EIGHT CHANNEL ANALOG TO APPLE® INTERFACE SYSTEM

OMEGA® *White Box™ Products*

- Real Time Clock
- User-friendly, Menu-driven Software
- Direct Readout in Engineering Units
- Analog Inputs
- 8 Digital Lines
- +5, +7, +12 and −12 Volt Excitation Supplies Available

THE A/D BOARD

- Use Any Card Slot: No External Power Required
- Fully Socketed
- Gold Plated Contacts
- Self Calibrating
- 14 Bits

2½ × 8¼

ANALOG
DIGITAL
POWER
OMEGASOFT™
OMEGASOFT™
OWNER'S MANUAL
OMEGA®
for Apple
Thermistors

Completely Assembled—
Just Plug it in!

THE SOFTWARE—Included

- Complete OMEGASOFT™ Instruction Manual
- Measure, Alarm, Record, and Output Automatically with an easy to use prompted program
- 16 Sector Disk

For Apple II Series with Disk Drive

WB-A10-A
$1270

To Order Call
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ENGINEERING, INC.
(203) 359-1660

OMEGA®

Sales Person ______________________

Action Order No. ______________________

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Telex 996404 Cable OMEGA FAX (203) 359-7700

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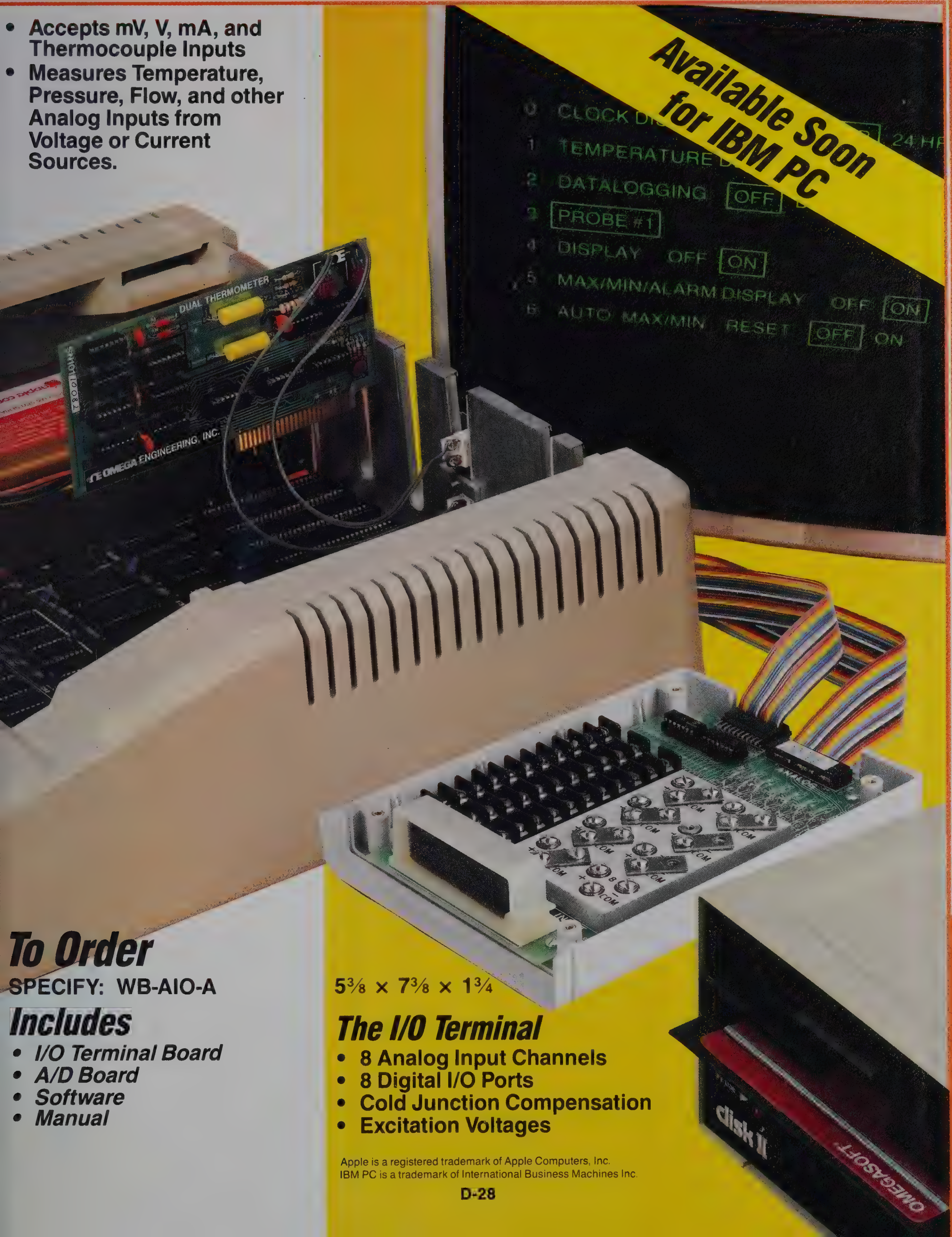
OMEGA® sells direct to all its customers.
Place this convenient card in your files.

- **Accepts mV, V, mA, and Thermocouple Inputs**
- **Measures Temperature, Pressure, Flow, and other Analog Inputs from Voltage or Current Sources.**


Available Soon for IBM PC
0 CLOCK DI
24 HR
1 TEMPERATURE D
2 DATALOGGING OFF
3 PROBE #1
4 DISPLAY OFF ON
5 MAX/MIN/ALARM DISPLAY OFF ON
6 AUTO MAX/MIN RESET OFF ON
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OMEGA ENGINEERING, INC.
COM
disk II
OMEGASOFT

To Order

SPECIFY: WB-AIO-A

Includes

- *I/O Terminal Board*
- *A/D Board*
- *Software*
- *Manual*

5⅜ × 7⅜ × 1¾

The I/O Terminal

- **8 Analog Input Channels**
- **8 Digital I/O Ports**
- **Cold Junction Compensation**
- **Excitation Voltages**

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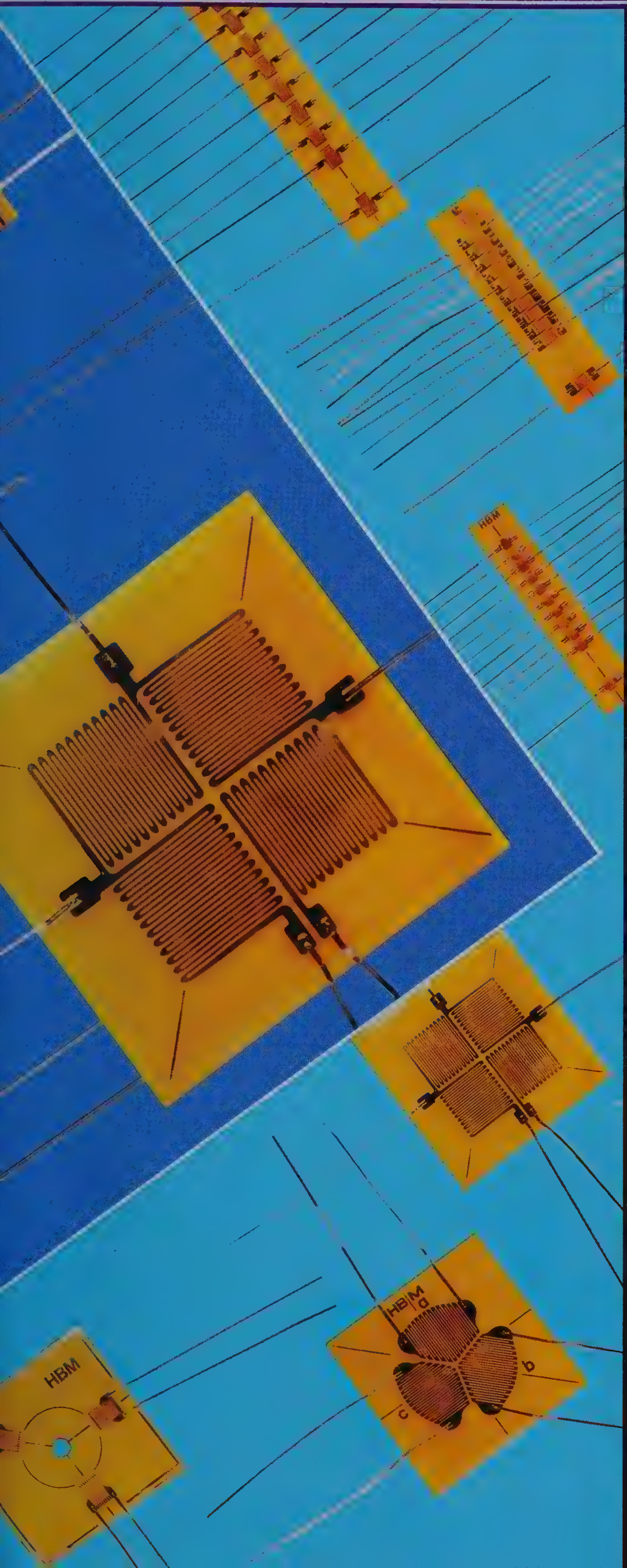
E

OMEGA®/HBM
Strain Gages, Accessories, and Instrumentation



Selection Guide E-3
Strain Gage Principles E-7
Y Series Strain Gages with 1 measuring grid E-37
Y Series Strain Gages with 2, 3 and 4 measuring grids E-39
Y Series Strain Gage Chains E-43
G Series Precision Strain Gages E-45
Special Strain Gages E-47
- Residual Stress
- High Temperature
- High Strain
- Encapsulated
- Weld-on

Adhesives for Strain Gages E-53
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Connectors for Strain Gages E-56
Application Kits for Strain Gages and Accessories E-57
Instrumentation for Strain Gages E-59

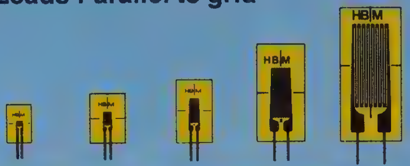
OMEGA® QUICK SELECTION GUIDE
Y SERIES FOIL STRAIN GAGES

Polyimid Carrier

1 MEASURING GRID

- **Ribbon Leads Parallel to grid**

pg. E-37

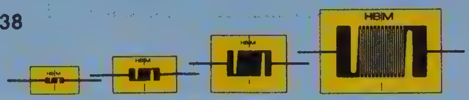


Diagrams to actual size.

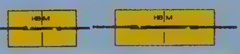
LY 11	0.6/120	1.5/120	**3/120**	**6/120**	10/120
for steel			**3/350**	**6/350**	10/350
LY 13	0.6/120	1.5/120	**3/120**	**6/120**	10/120
for aluminum			3/350	6/350	10/350

- **Ribbon Leads Perpendicular to grid**

pg. E-38



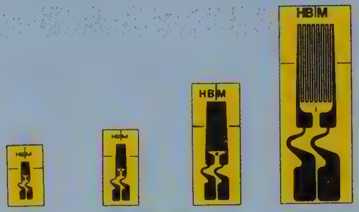
LY 21	0.6/12	1.5/120	**3/120**	**6/120**
for steel				



LY 51	3/120	6/120
for steel		
LY 58	3/120	6/120
for plastic		

- **Solder Pad Terminals with integral strain relief**

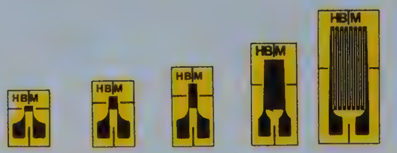
pg. E-38

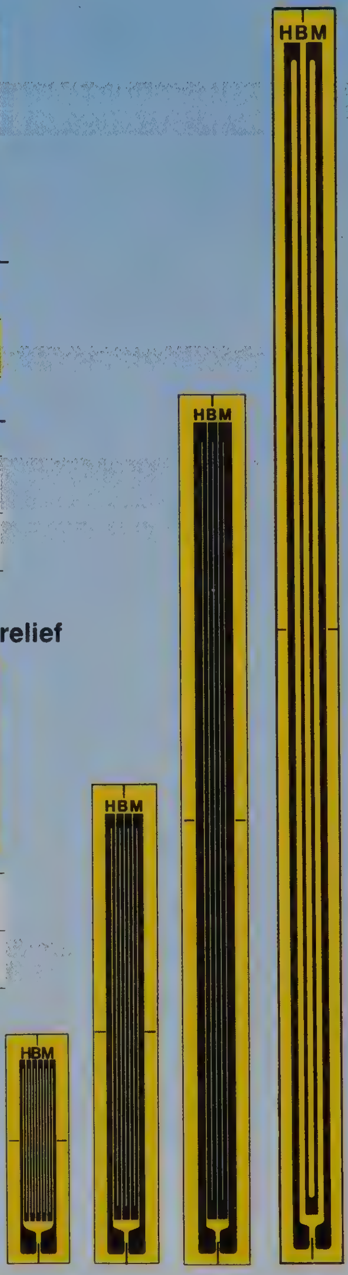


LY 61	1.5/120	**3/120**	**6/120**	10/120
for steel		3/350	6/350	10/350
LY 63	1.5/120	**3/120**	**6/120**	10/120
for aluminum			6/350	

- **Solder Pad Terminals**
- **50, 100, 150 mm Models for inhomogeneous material**

pg. E-39



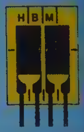


LY 41	0.6/120	1.5/120	**3/120**	**6/120**	10/120	20/120	50/120	100/120	150/120
for steel			3/350	6/350	10/350				
		1.5/350	3/700	6/700	10/700	20/700	50/700	100/700	150/700
LY 43	0.6/120	1.5/120	3/120	6/120	10/120	20/120	50/120	100/120	150/120
for aluminum			3/350	6/350	10/350				
		1.5/350	3/700	6/700	10/700	20/700	50/700	100/700	150/700

2 MEASURING GRIDS

- **Double Strain Gage**

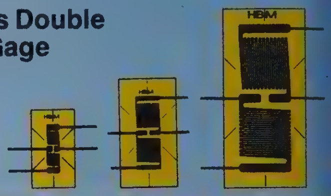
pg. E-40



DY 11	6/350
for steel	

- **90° Axis Double Strain Gage**

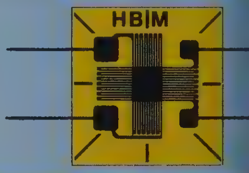
pg. E-40



XY 11	1.5/120	**3/120**	**6/120**
for steel		3/350	6/350
XY 13	1.5/120	3/120	6/120
for aluminum			

- **90° Axis with Stacked Grids**

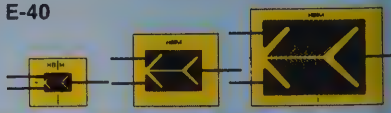
pg. E-40



XY 91	**3/120**	**6/120**	10/120
for steel			
XY 93	3/120	6/120	10/120
for steel			

- **45° Axis for Torque Measurement**

pg. E-40

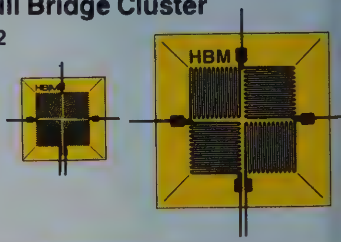


XY 21	1.5/120	**3/120**	**6/120**
for steel			6/350

4 MEASURING GRIDS

- **90° Full Bridge Cluster**

pg. E-42



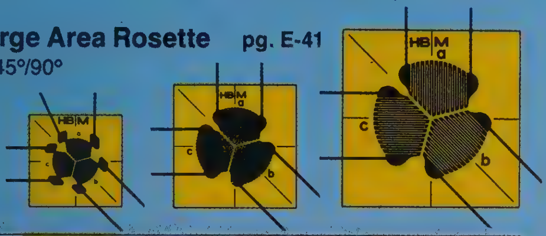
VY 11	**3/120**	6/120
for steel		

🟨 **HIGHLIGHTED MODELS ARE STOCKED**

OMEGA® QUICK SELECTION GUIDE
Y SERIES FOIL STRAIN GAGES
Polyimid Carrier

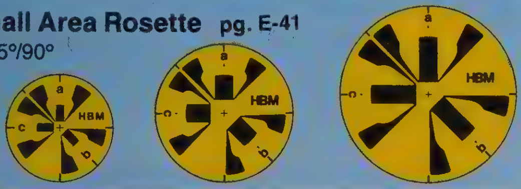
3 MEASURING GRIDS

- **Large Area Rosette** pg. E-41
  0°/45°/90°



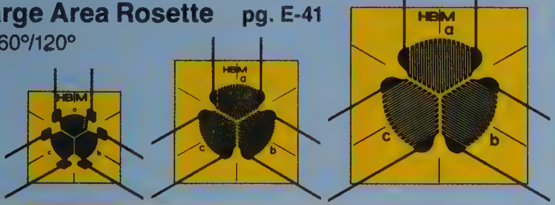
RY 11 for steel	**6/120**	10/120	15/120
RY 13 for aluminum	6/120	10/120	15/120

- **Small Area Rosette** pg. E-41
  0°/45°/90°



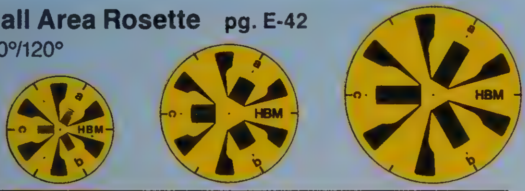
RY 31 for steel	**6/120**	10/120	15/120
RY 33 for aluminum	6/120	10/120	15/120

- **Large Area Rosette** pg. E-41
  0°/60°/120°



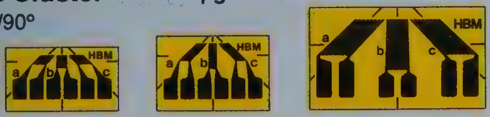
RY 41 for steel	**6/120**	10/120	15/120
RY 43 for aluminum	6/120	10/120	15/120

- **Small Area Rosette** pg. E-42
  0°/60°/120°



RY 71 for steel	**6/120**	10/120	15/120
RY 73 for aluminum	6/120	10/120	15/120

- **Edge Cluster** pg. E-42
  0°/45°/90°

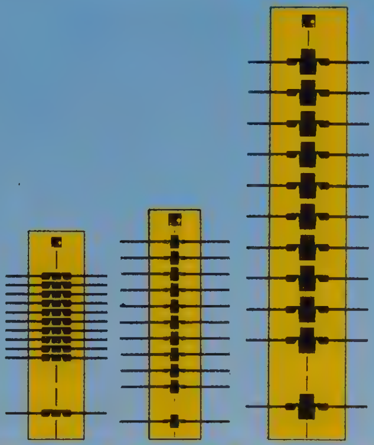


RY 81 for steel	1.5/120	**3/120**	**6/120**
RY 83 for aluminum	1.5/120	3/120	**6/120**

☐ ***HIGHLIGHTED MODELS ARE STOCKED***

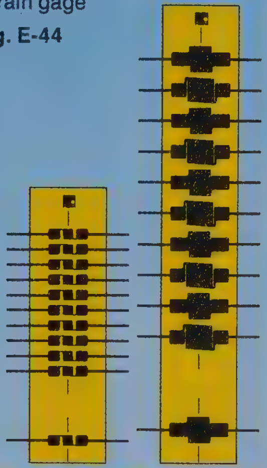
STRAIN GAGE CHAINS

- **10 Measuring Grids**
  Parallel to Axis
  plus 1 compensation
  strain gage
  pg. E-43



KY 11 for steel	1/120	**2/120**	4/120
KY 13 for aluminum	1/120	**2/120**	4/120

- **10 Measuring Grids**
  5 Parallel to Axis
  5 Perpendicular to Axis
  plus 1 compensation
  strain gage
  pg. E-44

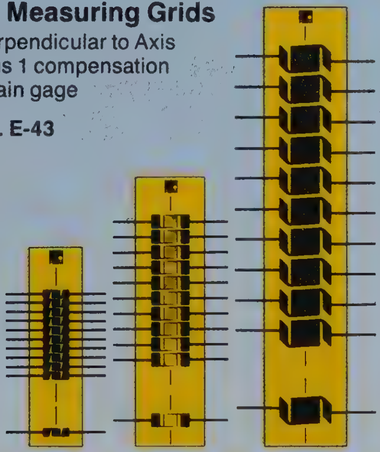


KY 41 for steel	**2/120**	4/120
KY 43 for aluminum	**2/120**	4/120 4/120

OMEGA DMD 20
Protective Coating SG 250
OMEGA

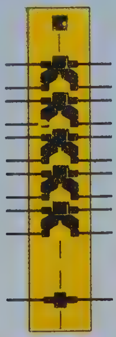
Instrumentation and Accessories, pg. E-53

- **10 Measuring Grids**
  Perpendicular to Axis
  plus 1 compensation
  strain gage
  pg. E-43



KY 21 for steel	1/120	**2/120**	4/120
KY 23 for aluminum	1/120	**2/120**	4/120

- **Cluster Chain**
  5 clusters of three strain gages
  0°/60°/120°
  plus 1 compensation
  strain gage
  pg. E-44



KY 31 for steel	4/120

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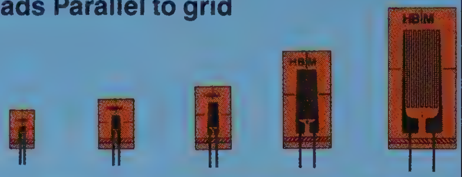
G SERIES STRAIN GAGES

Glass Fiber Phenolic Resin

1 MEASURING GRID

- Ribbon Leads Parallel to grid

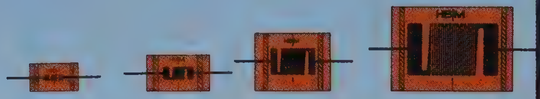
pg. E-46



LG 11	0.6/120	1.5/120	**3/120**	**6/120**	10/120
for steel			3/350	6/350	10/350
LG 13	0.6/120	1.5/120	**3/120**	**6/120**	10/120
for aluminum			3/350	6/350	10/350

- Ribbon Leads Perpendicular to grid

pg. E-46

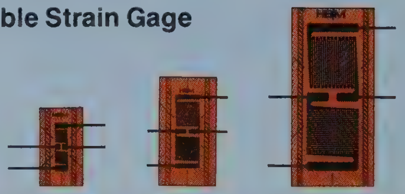


LG 21	0.6/12	1.5/120	**3/120**	**6/120**
for steel				

2 MEASURING GRIDS

- 90° Axis Double Strain Gage

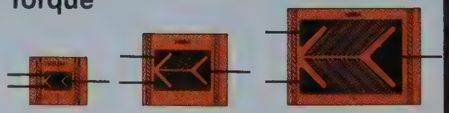
pg. E-46



XG 11	1.5/120	**3/120**	6/120
for steel		3/350	6/350

- 45° Axis for Torque

pg. E-46



XG 21	1.5/120	**3/120**	6/120
for steel			6/350

🟨 **HIGHLIGHTED MODELS ARE STOCKED**

SPECIAL STRAIN GAGES

FOR RESIDUAL STRESS

- Ring Core Rosette

pg. E-47

0°/90°

0°/45°/90°

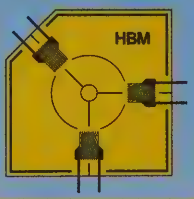
XY 51	5/350
for steel	

RY 51	5/350
for steel	

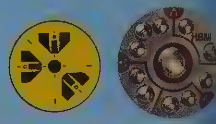
- Hole Drilling Rosette

pg. E-48

0°/45°/90°



0°/45°/90°



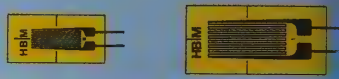
RY 21	**3/120**
for steel	

RY 61	**1.5/120**
for steel	

FOR HIGH STRAIN

- 10% Maximum Elongation

pg. E-50

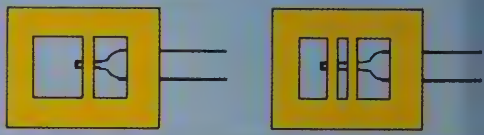


LD 20	**6/120**	10/120
for steel		

FOR HIGH TEMPERATURES

- 760°C

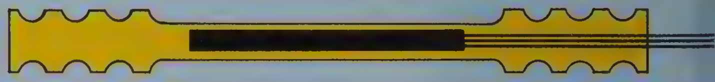
pg. E-49



LF 30	3/120	**6/120**

ENCAPSULATED STRAIN GAGES

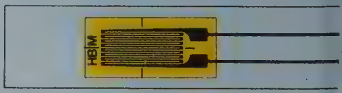
pg. E-51



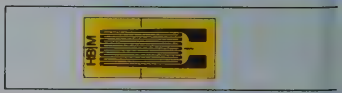
DA 3	**88/350**
for asphalt, ice & concrete	

WELD-ON STRAIN GAGE

pg. E-50



LS 52	6/350



LS 53	**6/350**

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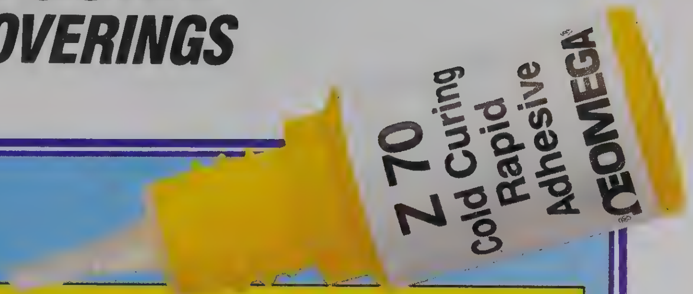
ADHESIVES AND PROTECTIVE COVERINGS



ADHESIVES

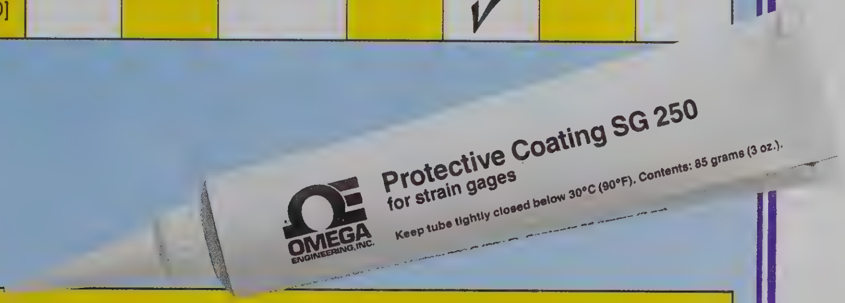
- Complete details on page E-53.

Potential Uses and Temperature Limits

Strain gage adhesive	Price	Temperature limits in °C [°F]			foil gages series Y	foil gages series G	residual stress gages XY, RY	gages for high strains LD	high temperature gages LF	encapsulated gages LS	encapsulated gages DB, DA
		lower, with stat./dyn. load	upper, with static load	upper, with dynamic load							
X 60 Kit 100 g cold curing rapid adhesive	$25.00	−200 [−330]	+60 [+140]	+80 [+175]	✔	✓	✔	✔		✔	✔
Z 70 10 cm^3 cold curing rapid adhesive	9.50	−200 [−330]	+100 [+210]	+120 [+250]	✔	✓	✔	✔			
EP 310 Kit 80 cm^3 hot curing adhesive	63.00	−270 [−455]	+310 [+590]	+310 [+590]	✔	✔		✔			
CR 760 25 g ceramic putty	75.50	−200/−230 [−330/−380]	+760 [+1400]	+850 [+1560]					✔		

✔ **Ideal application**

✓ **Limited application (check specs)**


Protective Coating SG 250
for strain gages
Keep tube tightly closed below 30°C (90°F). Contents: 85 grams (3 oz.).
OMEGA
ENGINEERING, INC.

PROTECTIVE COVERINGS

- Complete details on page E-55.

Potential Uses and Temperature Limits

Protective cover	Price	Protects against	Temperature limit of the stability in air in °C [°F]
AK 22 tenacious putty 1 kilogram	$16.00	mechanical action weather water (no vapor) pressurized water up to 400 bar	−50 ... +170 [−58 ... +340]
ABM 75 aluminum foil with knead-on material 11-205 × 100 mm pieces	17.00	mechanical action (Al foil must not be damaged) weather water	−196 ... + 75 [−321 ... +167]
SG 250 transparent silicon rubber 85 g tube	22.00	mechanical action weather, oil water at room temperature	−70 ... +260 [−94 ... +500]
PU 100 polyurethane varnish 4-30 ml bottles	23.00	mechanical action weather oil solvents	−32 ... +100 [−26 ... +212]
Thermcoat SL transparent silicon resin (2 oz.)	9.00	weather oil solvents	−145 ... +232 [−230 ... +450]

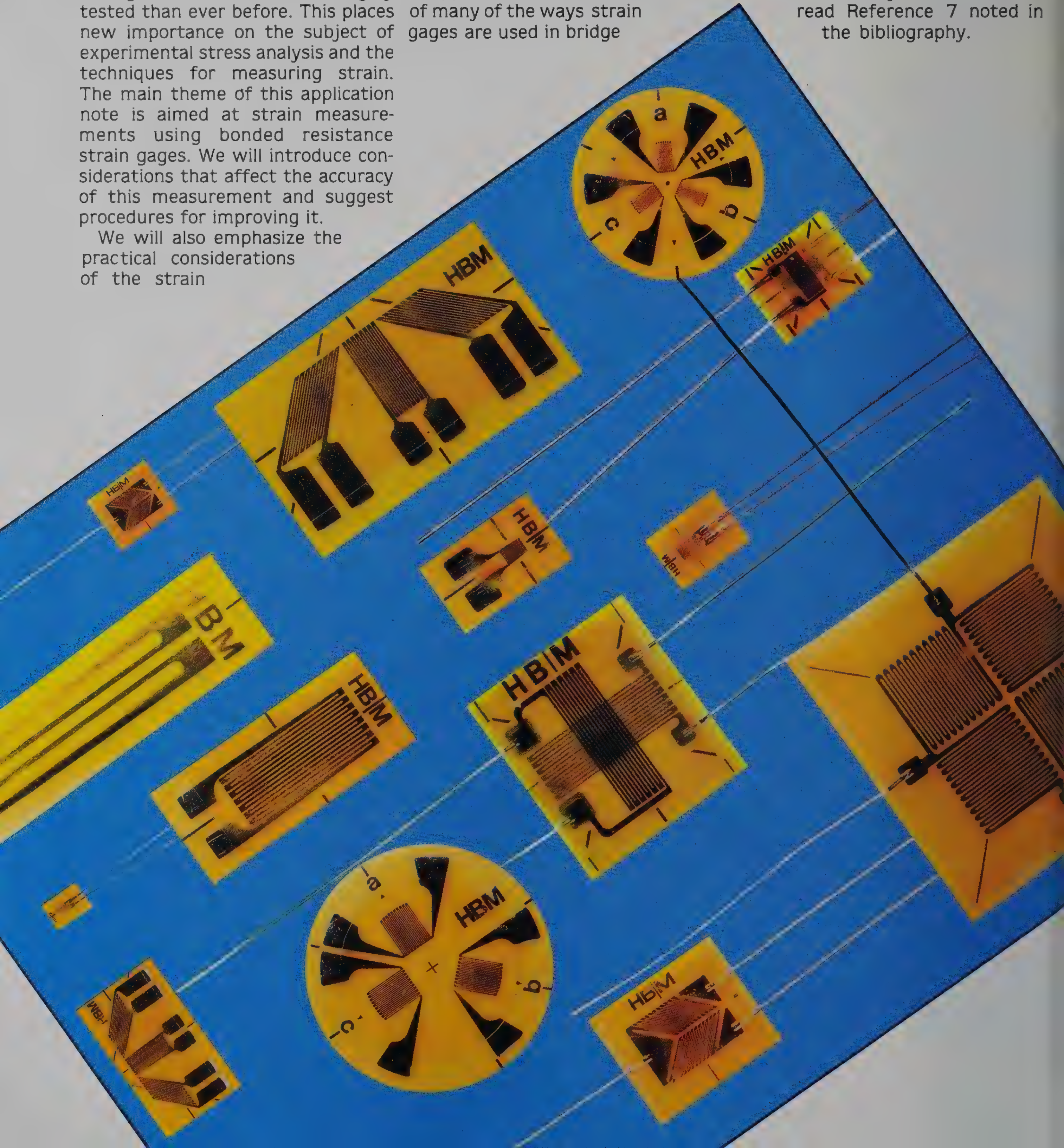
PRACTICAL STRAIN GAGE MEASUREMENTS

Introduction

With today's emphasis on product liability and energy efficiency, designs must not only be lighter and stronger, but also more thoroughly tested than ever before. This places new importance on the subject of experimental stress analysis and the techniques for measuring strain. The main theme of this application note is aimed at strain measurements using bonded resistance strain gages. We will introduce considerations that affect the accuracy of this measurement and suggest procedures for improving it.

We will also emphasize the practical considerations of the strain gage measurement, with an emphasis on computer controlled instrumentation.

Appendix B contains schematics of many of the ways strain gages are used in bridge circuits and the equations which apply to them. Readers wishing a more thorough discussion of bridge circuit theory are invited to read Reference 7 noted in the bibliography.



Symbols

σ	normal stress
τ	shear stress
ϵ	strain (normal)
$\mu\epsilon$	micro-strain (ϵ x 10^6)
γ	shear strain
E	modulus of elasticity or Young's modulus
ν	Poisson ratio
GF	gage factor
R_g	gage resistance in ohms
K_t	transverse sensitivity ratio
L	length
ΔL	change in length
ΔR_g	change in gage resistance (due to strain)
%ΔGF	% change in gage factor (due to temperature)
R_ℓ	lead wire resistance
T	temperature in °C
V_{IN}	Bridge excitation voltage
V_{OUT}	Bridge output voltage

$$V_r \quad \left[(V_{OUT}/V_{IN})_{[strained]} - (V_{OUT}/V_{IN})_{[unstrained]}\right]$$

tress and Strain

The relationship between stress nd strain is one of the most funamental concepts from the study f mechanics of materials and is of aramount importance to the stress nalyst. In experimental stress nalysis we apply a given load and hen measure the strain on inividual members of a structure or achine. Then we use the stresstrain relationships to compute the tresses in those members to verify hat these stresses remain within he allowable limits for the parcular materials used.

train

When a force is applied to a body, he body deforms. In the general ase this deformation is called train. In this application note we vill be more specific and define the erm STRAIN to mean deformation er unit length or fractional change n length and give it the symbol, ϵ. ee Figure 1. This is the strain that ve typically measure with a bonded esistance strain gage. Strain may e either tensile (positive) or comressive (negative). See Figure 2. /hen written in equation form, $= \Delta L/L$, we see that strain is a atio and therefore dimensionless. To maintain the physical significance of strain, it is often written with units of inch/inch. For most metals the strains measured in experimental work are typically less than 0.005000 inch/inch. Since practical strain values are so small, they are often expressed in micro-strain which is ϵ x 10^6 (note this is equivalent to parts per million or ppm) and has the symbol, $\mu\epsilon$. Still another way to express strain is as percent strain, which is ϵ x 100. For example: 0.005 inch/inch = 5000 $\mu\epsilon$ = 0.5%.

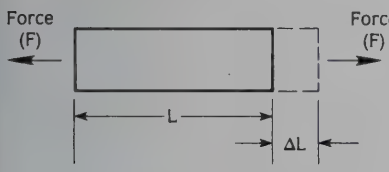


Figure 1: Uniaxial Force Applied

As described to this point, strain is fractional change in length and is directly measurable. Strain of this type is also often referred to as normal strain.

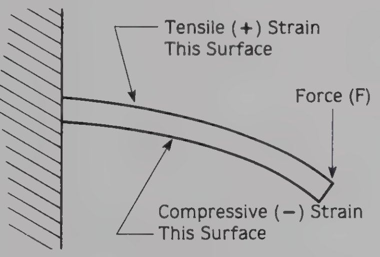


Figure 2: Cantilever in Bending

Shearing Strain

Another type of strain called SHEARING STRAIN is a measure of angular distortion. Shearing strain is also directly measurable but not as easily as normal strain. If we had a thick book sitting on a table top and we applied a force parallel to the covers, we could see the shear strain by observing the edges of the pages. See Figure 3. Shearing strain, γ, is defined as the angular change in radians between two line segments that were orthogonal in the undeformed state. Since this angle is very small for most metals, shearing strain is approximated by the tangent of the angle.

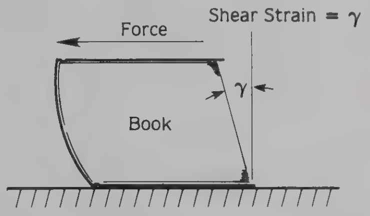


Figure 3: Visualizing Shearing Strain

Poisson Strain

In Figure 4 is a bar with a uniaxial tensile force applied, like the bar in Figure 1. The dashed lines show the shape of the bar after deformation, pointing out another phenomenon, that of Poisson strain. The dashed lines indicate that the bar not only elongates but that its girth contracts. This contraction is a strain in the transverse direction due to a property of the material known as Poisson's Ratio. Poisson's ratio, ν, is defined as the negative ratio of the

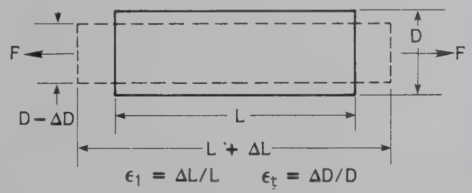


Figure 4: Poisson Strain

Stress and Strain (continued)

strain in the transverse direction to the strain in the longitudinal direction. It is interesting to note that no stress is associated with the Poisson strain. Referring to Figure 4, the equation for Poisson's ratio is $\nu = -\epsilon_t/\epsilon_1$. Note that ν is dimensionless.

Normal Stress

While forces and strains are measurable quantities used by the designer and stress analyst, stress is the term used to compare the loading applied to a material with its ability to carry the load. Since it is usually desirable to keep machines and structures as small and light as possible, the parts should be stressed, in service, to the highest permissible level. STRESS refers to force per unit area on a given plane within a body.

The bar in Figure 5 has a uniaxial tensile force, F, applied along the x-axis. If we assume the force to be uniformly distributed over the cross-sectional area, A, the "average" stress on the plane of the section is F/A. This stress is perpendicular to the plane and is called NORMAL STRESS, σ. Expressed in equation form, $\sigma = \mathbf{F/A}$, and has units of force per unit area. Since the normal stress is in the x direction and there is no component of force in the y direction, there is no normal stress in that direction. The normal stress is in the positive x direction and is tensile.

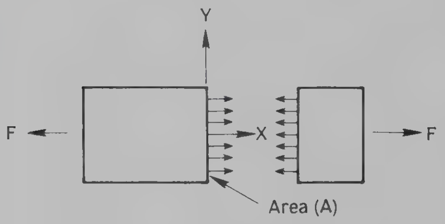


Figure 5: Normal Stress

Shear Stress

Just as there are two types of strains, there is also a second type of stress called SHEAR STRESS. Where normal stress is normal to the designated plane, shear stress is parallel to the plane and has the symbol, τ. In the example shown in Figure 5, there is no y component of force, therefore no force parallel to the plane of the section, so there is no shear stress on that plane. Since the orientation of the plane is arbitrary, what happens if the plane is oriented other than normal to the line of action of the applied force? Figure 6 demonstrates this concept with a section taken on the n-t coordinate system at some arbitrary angle, ϕ, to line of action of the force.

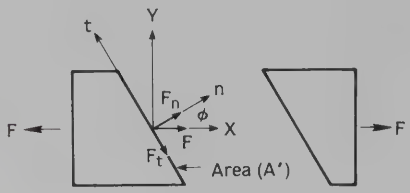


Figure 6: Shear Stress

We see that the force vector, F, can be broken into two components, F_n and F_t, that are normal and parallel to the plane of the section. This plane has a cross-sectional area of A'and has both normal and shear stresses applied. The average normal stress, σ, is in the n direction and the average shear stress, τ, is in the t direction. Their equations are: $\sigma = \mathbf{F_n/A'}$ and $\tau = \mathbf{F_t/A'}$. Note that it was the force vector that was broken into components, not the stresses, and that the resulting stresses are a function of the orientation of the section. This means that stresses (and strains), while having both magnitude and direction, are not vectors and do not follow the laws of vector addition, except in certain special cases, and they should not be treated as such. We should also note that stresses are derived quantities, computed from other measurable quantities, and are not directly measurable. [3]

Principal Axes

In the preceding examples the x-y axes are also the PRINCIPAL AXES for the uniaxially loaded bar. By definition, the principal axes are the axes of maximum and minimum normal stress. They have the additional characteristic of zero shear stress on the planes that lie along these axes. In Figure 5 the stress in the x direction is the maximum normal stress, and we noted that there was no force component in the y direction and therefore zero shear stress on the plane. Since there is no force in the y direction, there is zero normal stress in the y direction and in this case zero is the minimum normal stress. So the requirements for the principal axes are met by the x-y axes. In Figure 6 the x-y axes are the principal axes since that bar is also loaded uniaxially. The n-t axes in Figure 6 do not meet the zero shear stress requirement of the principal axes. The corresponding STRAINS on the principal axes are also maximum and minimum and the shear strain is zero.

The principal axes are very important in stress analysis because the magnitudes of the maximum and minimum normal stresses are usually the quantity of interest. Once the principal stresses are known then the normal and shear stresses in any orientation may be computed. If the orientation of the principal axes are known, through knowledge of the loading conditions or experimental techniques, the task of measuring the strains and computing the stresses is greatly simplified.

In some cases we are interested in the average value of stress or load on a member, but often we want to determine the magnitude of the stresses at a point. The material will fail at the point where the stress exceeds the load-carrying capacity of the material. This failure may occur because of excessive tensile or compressive normal stress or excessive shearing stress. In actual structures the area of this excessive stress level may be quite small. The usual method of diagramming the stress at a point is to use an infinitesimal element that surrounds the point of interest. The stresses are then a function of the orientation of this element, and in one particular orientation, the element will have its sides parallel to the principal axes. This is the orientation that gives the maximum and minimum normal stresses on the point of interest.

Stress-Strain Relationships

Now that we have defined stress and strain we need to explore the stress-strain relationship, for it is this relationship that allows us to calculate stresses from the measured strains. If we have a bar made of mild steel and incrementally load t in uniaxial tension and plot the strain versus the normal stress in the direction of the applied load, the plot will look like the stress-strain diagram in Figure 7.

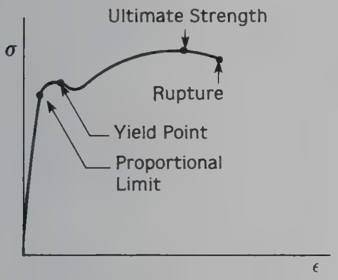


Figure 7: Stress-Strain Diagram for Mild Steel

From Figure 7 we can see that up to a point, called the proportional imit, there is a linear relationship between stress and strain. Hooke's Law describes this relationship. The slope of this straight line portion of the stress-strain diagram is the MODULUS OF ELASTICITY or YOUNG'S MODULUS for the material. The modulus of elasticity, E, has the same units as stress (force per unit area) and is determined experimentally for materials. Written in equation form this stress-strain relationship is $\sigma = \mathbf{E} \bullet \epsilon$. Some materials, for example cast iron and concrete, do not have a linear portion to their stress-strain diagrams. To do accurate stress analysis studies for these materials it is necessary to determine the stress-strain properties, including Poisson's ratio, for the particular material on a testing machine. Also, the modulus of elasticity may vary with temperature. This variation may need to be experimentally determined and considered when performing stress analysis at temperature extremes. There are two other points of interest on the stress-strain diagram in Figure 7, the yield point and the ultimate strength value of stress. The yield point is the stress level at which strain will begin to increase rapidly with little or no increase in stress. If the material is stressed beyond the yield point, and then the stress is removed, the material will not return to its original size but will retain a residual offset or strain. The ultimate strength is the maximum stress developed in the material before rupture.

The examples we have examined to this point have been examples of uniaxial forces and stresses. In experimental stress analysis the biaxial stress state is the most common. Figure 8 shows an example of a shaft with both tension and torsion applied. The point of interest is surrounded by an infinitesimal element with its sides oriented parallel to the x-y axes. The point has a biaxial stress state and a triaxial strain state (remember Poisson's ratio). The element, rotated to be aligned with the principal (p-q) axes, is also shown in Figure 8. Figure 9 shows the element removed with arrows added to depict the stresses at the point for both orientations of the element.

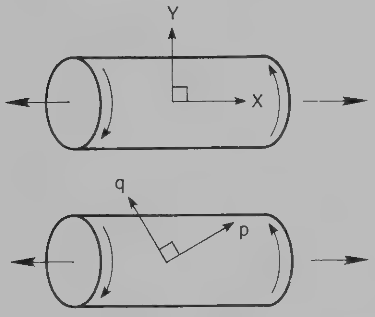


Figure 8: Shaft in Torsion and Tension

We see that the element oriented along the x-y axes has a normal stress in the x direction, zero normal stress in the y direction and shear stresses on its surfaces. The element rotated to the p-q axes orientation has normal stress in both directions but zero shear stress as it should, by definition, if the p-q axes are the principal axes. The normal stresses, σ_p and σ_q, are the maximum and minimum normal stresses for the point. The strains in the p-q direction are also the maximum and minimum, and there is zero shear strain along these axes. Appendix C gives the equations relating stress to strain for the biaxial stress state.

If we know the orientation of the principal axes, we can then measure the strain in those directions and compute the maximum and minimum normal stresses and the maximum shear stress, for a given loading condition. We don't always know the orientation of the principal axes, but if we measure the strain in three separate directions, we can compute the strain in any direction including the principal axes directions. Three and four element rosette strain gages are used to measure the strain when the principal axes orientation is unknown. The equations for computing the orientation and magnitudes of the principal strains from 3-element rosette strain data are found in Appendix C.

For further study of mechanics of materials refer to References [1, 4, 6] noted in the bibliography. Properties of several common engineering materials are listed in Appendix A.

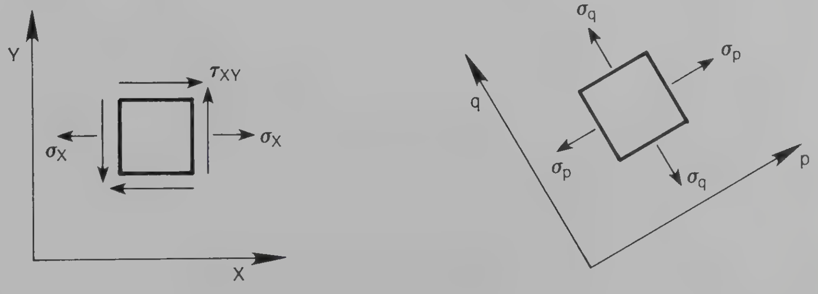


Figure 9: Element on X-Y Axes and Principal Axes

Measuring Strain

Stress in a material can't be measured directly. It must be computed from other measurable parameters. Therefore the stress analyst uses measured strains in conjunction with other properties of the material to calculate the stresses for a given loading condition. There are methods of measuring strain or deformation based on various mechanical, optical, acoustical, pneumatic, and electrical phenomena. This section briefly describes several of the more common methods and their relative merits.

Gage Length

The measurement of strain is the measurement of the displacement between two points some distance apart. This distance is the GAGE LENGTH and is an important comparison between various strain measurement techniques. Gage length could also be described as the distance over which the strain is averaged. For example, we could, on some simple structure such as the part in Figure 10, measure the part length with a micrometer both before and during loading. Then we would subtract the two readings to get the total deformation of the part. Dividing this total deformation by the original length would yield an average value of strain for the entire part. The gage length would be the original length of the part.

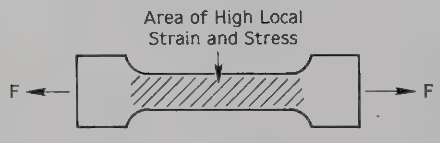


Figure 10

If we used this technique on the part in Figure 10, the strain in the reduced width region of the part would be locally higher than the measured value because of the reduced cross-sectional area carrying the load. The stresses will also be highest in the narrow region and the part will yield there before the measured average strain value indicates a magnitude of stress greater than the yield point of the material.

Ideally, we want the strain measuring device to have an infinitesimal gage length so we can measure strain at a point. If we had this ideal strain gage we would place it in the narrow portion of the specimen in Figure 10 to measure the high local strain in that region. Other desirable characteristics for this ideal strain measuring device are small size and mass, easy attachment, high sensitivity to strain, low cost and low sensitivity to temperature and other ambient conditions. [2,6]

Mechanical Devices

The earliest strain measurement devices were mechanical in nature. We have already considered an example using a micrometer to measure strain and observed a problem with that approach. Extensometers are a class of mechanical devices used for measuring strain that employ a system of levers to amplify the minute strains to a level that can be read. A minimum gage length of 1/2 inch and a resolution of about 10 $\mu\epsilon$ is the best that can be achieved with purely mechanical devices. The addition of light beam and mirror arrangements to extensometers improves resolution and shortens gage length, allowing 2 $\mu\epsilon$ resolution and gage lengths down to 1/4 inch.

Still another type of device, the photoelectric gage, uses a combination of mechanical, optical, and electrical amplification to measure strain. This is done by using a light beam, two fine gratings and a photocell detector to generate an electrical current that is proportional to strain. This device comes in gage lengths as short as 1/16 inch but it is costly and delicate. All of these mechanical devices tend to be bulky and cumbersome to use, and most are only suitable for static strain measurements.

Optical Methods

Several optical methods are used for strain measurement. One of these techniques uses the interference fringes produced by optical flats to measure strain. This device is sensitive and accurate but the technique is so delicate that laboratory conditions are required for its use. Reference 5 in the bibliography gives excellent introductions to the optical methods of photoelasticity, holography, and moire' methods of strain analysis. [2,5]

Electrical Devices

Another class of strain measuring devices depends on electrical characteristics which vary in proportion to the strain in the body to which the device is attached. Capacitance and inductance strain gages have been constructed but sensitivity to vibration, mounting difficulties, and complex circuit requirements keep them from being very practical for stress analysis work. These devices are, however, often employed in transducers. The piezoelectric effect of certain crystals has also been used to measure strain. When a crystal strain gage is deformed or strained a voltage difference is developed across the face of the crystal. This voltage difference is proportional to the strain and is of a relatively high magnitude. Crystal strain gages are fairly bulky, very fragile, and not suitable for measuring static strains.

Probably the most important electrical characteristic which varies in proportion to strain is that of electrical resistance. Devices whose output depend on this characteristic are the piezoresistive or semiconductor gage, the carbon-resistor gage, and the bonded metallic wire and foil resistance gages. The carbon-resistor gage is the forerunner of the bonded resistance wire strain gage. It is low in cost, can have a short gage length, and is very sensitive to strain. A high sensitivity to temperature and humidity are the disadvantages of the carbon-resistor strain gage.

The semiconductor strain gage is based on the piezoresistive effect in certain semiconductor materials such as silicon and germanium.

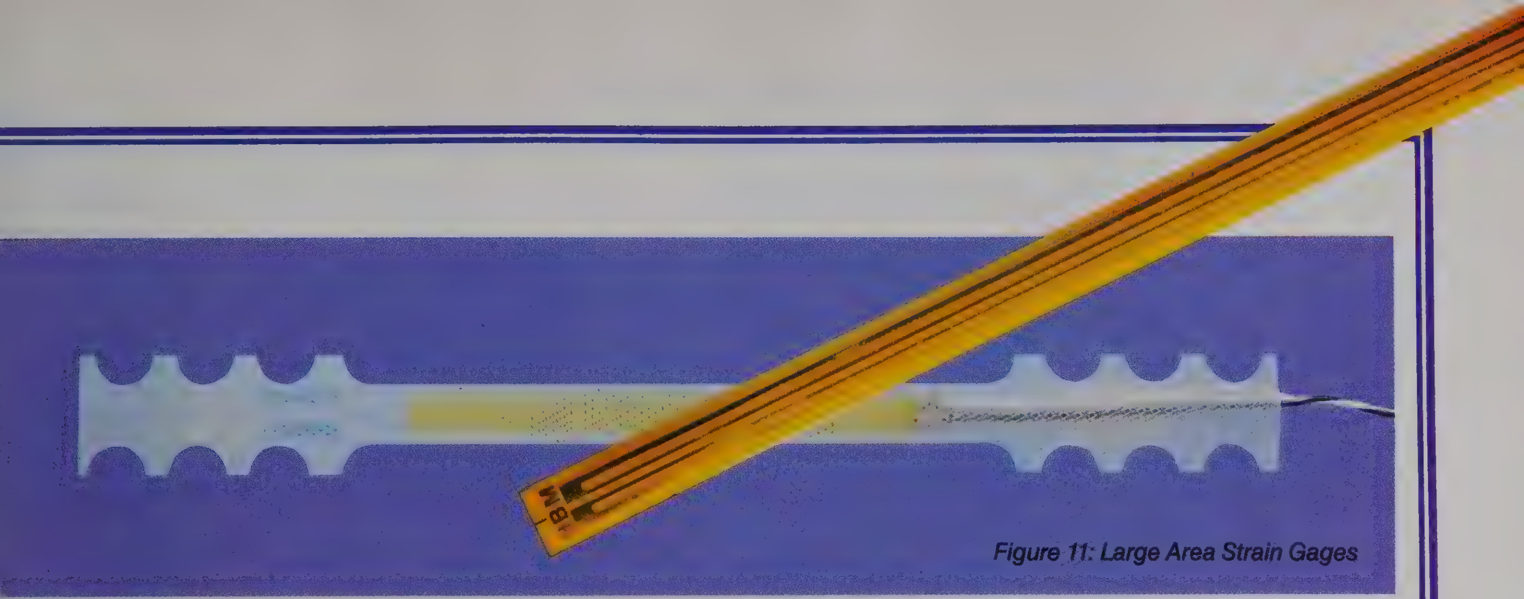


Figure 11: Large Area Strain Gages

Semiconductor gages have elastic behavior and can be produced to have either positive or negative resistance changes when strained. They can be made physically small while still maintaining a high nominal resistance. The strain limit for these gages is in the 1000 to 10000 $\mu\epsilon$ range with most tested to 3000 $\mu\epsilon$ in tension. Semiconductor gages exhibit a high sensitivity to strain but the change in resistance with strain is nonlinear. Their resistance and output are temperature sensitive and the high output, resulting from changes in resistance as large as 10-20%, can cause measurement problems when using the devices in a bridge circuit. However, mathematical corrections for the temperature sensitivity, the nonlinearity of output, and the nonlinear characteristics of the bridge circuit (if used), can be made automatically when using computer controlled instrumentation to measure strain with semiconductor gages. They can be used to measure both static and dynamic strains. When measuring dynamic strains temperature effects are usually less mportant than for static strain measurements and the high output of the semiconductor gage is an asset.

The bonded resistance strain gage s by far the most widely used strain measurement tool for today's experimental stress analyst. It consists of a grid of very fine wire, or more recently of thin metallic foil, bonded o a thin insulating backing called a carrier matrix. The electrical resistance of this grid material varies inearly with strain. In use the carrier matrix is attached to the test specimen with an adhesive. When the specimen is loaded, the strain on its surface is transmitted to the grid material by the adhesive and carrier system. The strain in the specimen is found by measuring the change in the electrical resistance of the grid material. Figure 12 is a picture of a bonded resistance strain gage with a constantan foil grid and polyimide carrier material. The bonded resistance strain gage is low in cost, can be made with a short gage length, is only moderately affected by temperature changes, has small physical size and low mass, and has fairly high sensitivity to strain. It is suitable for measuring both static and dynamic strains. The remainder of this application note deals with the instrumentation considerations for making accurate, practical strain measurements using the bonded resistance strain gage. [2,5,6]

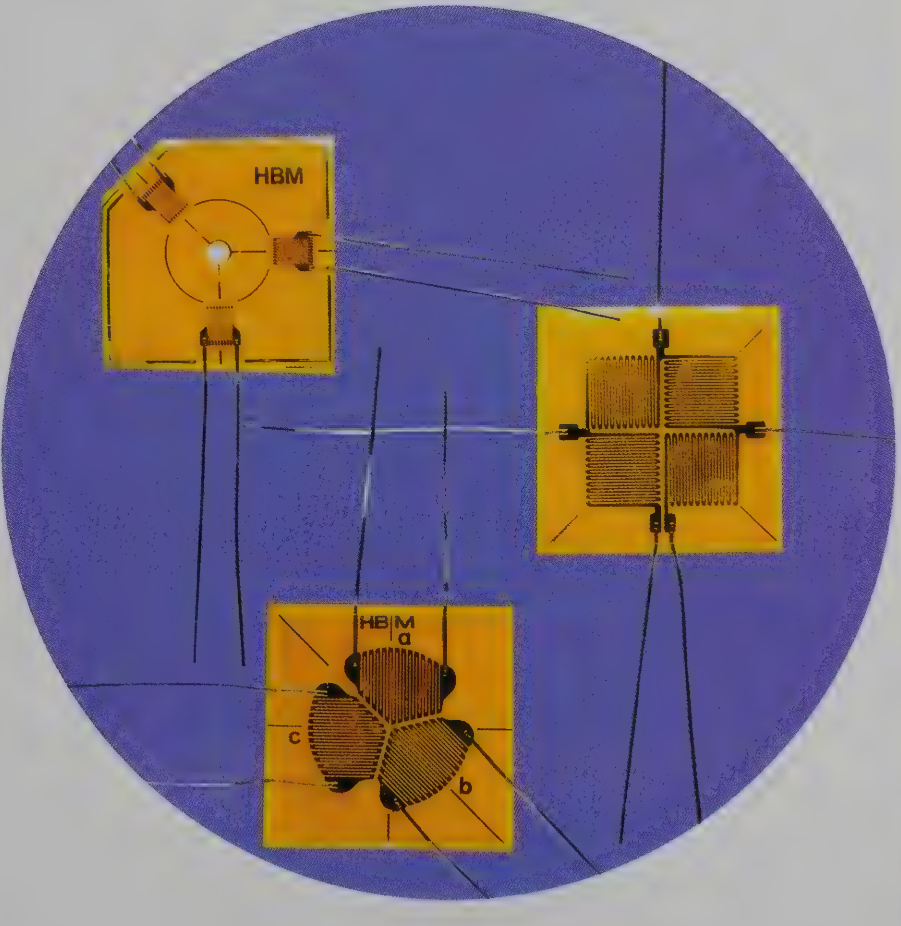


Figure 12: Foil Bonded Resistance Strain Gages

The Bonded Resistance Strain Gage

The term "bonded resistance strain gage" can apply to the nonmetallic (semiconductor) gage or to the metallic (wire or foil) gage. Wire and foil gages operate on the same basic principles and both can be treated in the same fashion from the measurement standpoint. The semiconductor gage, having a much higher sensitivity to strain than metallic gages, can have other considerations introduced into its measurement. We will use the term STRAIN GAGE or GAGE to refer to the BONDED METALLIC FOIL GRID RESISTANCE STRAIN GAGE throughout the rest of this application note. These foil gages are sometimes referred to as metal-film gages.

Strain gages are made with a printed circuit process using conductive alloys rolled to a thin foil. The alloys are processed, including controlled-atmosphere heat treating, to optimize their mechanical properties and temperature coefficient of resistance. A grid configuration for the strain sensitive element is used to allow higher values of gage resistance while maintaining short gage lengths. Gage resistance values range from 30 to 3000 ohms, with 120 ohm and 350 ohm being the most commonly used values for stress analysis. Gage lengths from 0.008 inch to 4 inches are commercially available. The conductor in a foil grid gage has a large surface area for a given cross-sectional area. This keeps the shear stress low in the adhesive and carrier matrix as the strain is transmitted by them. This larger surface area also allows good heat transfer between grid and specimen. Strain gages are small and light, will operate over a wide temperature range and can respond to both static and dynamic strains. They have wide application and acceptance in transducers as well as stress analysis.

In a strain gage application, the carrier matrix and the adhesive must work together to faithfully transmit the strains from the specimen to the grid. They also serve as an electrical insulator between the grid and the specimen and must transfer heat away from the grid. Three primary factors influencing gage selection are operating temperature, state of strain (including gradients, magnitude and time dependence) and stability requirements for the gage installation. The importance of selecting the proper combination of carrier material, grid alloy, adhesive, and protective coating for the given application cannot be over-emphasized. Strain gage manufacturers are the best source of information on this topic and have many excellent publications to assist the customer in selecting the proper strain gages, adhesives and protective coatings.

Gage Factor

When a metallic conductor is strained it undergoes a change in electrical resistance, and it is this change that makes the strain gage a useful device. The measure of this resistance change with strain is GAGE FACTOR, GF. Gage factor is defined as the ratio of the fractional change in resistance to the fractional change in length (strain) along the axis of the gage. Gage factor is a dimensionless quantity and the larger the value the more sensitive the strain gage. Gage factor is expressed in equation form as:

$$\mathrm{GF} = \frac{\Delta R/R}{\Delta L/L} = \frac{\Delta R/R}{\epsilon}$$

Equation No. 10

It should be noted that the change in resistance with strain is not just due to the dimensional changes in the conductor, but that the resistivity of the conductor material also changes with strain. The term gage factor applies to the strain gage as a whole, complete with carrier matrix, not just to the strain sensitive conductor. The gage factor for constantan and nickel-chromium alloy strain gages is nominally 2 and various gage and instrumentation specifications are usually based on this nominal value.

Transverse Sensitivity

If the strain gage were a single straight length of conductor, of small diameter with respect to its length, it would respond to strain along its longitudinal axis and be essentially insensitive to strain perpendicular or transverse to this axis. For any reasonable value of gage resistance it would also have a very long gage length. When the conductor is in the form of a grid to reduce the effective gage length, there are small amounts of strain sensitive material in the end loops or turn-arounds that lie transverse to the gage axis. See Figure 13. This end loop material gives the gage a non-zero sensitivity to strain in the transverse direction. TRANSVERSE SENSITIVITY FACTOR, K_t, is defined by:

$$K_t = \frac{\mathrm{GF(transverse)}}{\mathrm{GF(longitudinal)}},$$

and is usually expressed in percent. Values of K range from 0 to 10%.

To minimize this effect, extra material is added to the conductor in the end loops and the grid lines are kept close together. This serves to minimize the resistance in the transverse direction. Correction for transverse sensitivity may be necessary for short, wide-grid gages, or where there is considerable misalignment between the gage axis and the principal axis, or in rosette analysis where high transverse strain fields may exist. Data supplied by the manufacturer with the gage can be entered into the computer controlling the instrumentation and corrections for transverse sensitivity made to the strain data as it is collected.

Temperature Effects

Ideally we would prefer the strain gage to change resistance only in response to the stress-induced strain in the test specimen, but the resistivity and the strain sensitivity of all known strain sensitive materials vary with temperature. Of course that means the gage resistance and the gage factor will change when the temperature changes. This change in resistance with temperature for a mounted strain

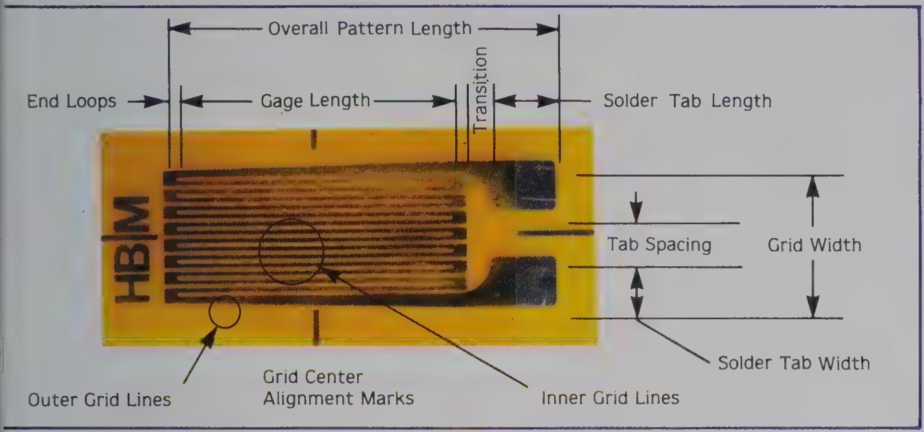


Figure 13: Strain Gage Nomenclature

age is a function of the difference h the thermal expansion coeffiients between the gage and the pecimen and of the thermal coeffiient of resistance of the gage alloy. elf-temperature compensating ages may be produced for specific naterials by processing the strain ensitive alloy such that it has thernal resistance characteristics that ompensate for the effects of the nismatch in thermal expansion coeficients between the gage and the pecific material. A temperature ompensated gage produced in this nanner is accurately compensated nly when mounted on a material hat has a specific coefficient of hermal expansion. Table 2 is a list f common materials for which selfemperature compensated gages re available.

Approximate Thermal Expansion Coefficient	
Material	PPM/°C
Quartz	0.5
Titanium	9
Mild Steel	11
Stainless Steel	16
Aluminum	23
Magnesium	26

Table 2
hermal Expansion Coefficients of Some ommon Materials for which Temperature ompensated Strain Gages Are Available

The compensation is only effective ver a limited temperature range ecause of the nonlinear character f both the thermal coefficients of expansion and the thermal coefficient of resistance.

The Measurement

From the gage factor equation we see that it is the FRACTIONAL CHANGE in resistance that is the important quantity rather than the absolute resistance value of the gage. Let's see just how large this resistance change will be for a strain of 1 $\mu\epsilon$. If we use a 120 ohm strain gage with a gage factor of +2, the gage factor equation tells us that 1 $\mu\epsilon$ applied to a 120 ohm gage produces a change in resistance of

$$\Delta R = 120 x 0.000001 x 2 = 0.000240 \text{ ohms,}$$

or 240 micro-ohms. That means we need to have micro-ohm sensitivity in the measuring instrumentation. Since it is the fractional change in resistance that is of interest and since this change will likely be only tens of milliohms, some reference point is needed from which to begin the measurement. The nominal value of gage resistance has a tolerance equivalent to several hundred microstrain and will usually change when the gage is bonded to the specimen, so this nominal value can't be used as a reference.

An initial, unstrained, gage resistance is used as the reference from which strain is measured. Typically the gage is mounted on the test specimen and wired to the instrumentation while the specimen is maintained in an unstrained state. A reading taken under these conditions is the unstrained reference value and applying a strain to the specimen will result in a resistance change from this value. If we had an ohmmeter that was accurate and sensitive enough to make the measurement, we would measure the unstrained gage resistance and then substract this unstrained value from the subsequent strained values. Dividing the result by the unstrained value would give us the fractional resistance change caused by strain in the specimen. In some cases it is practical to use just this method, and these cases will be discussed in a later section of this application note. A more sensitive way of measuring small changes in resistance is with the use of the Wheatstone bridge circuit and in fact most instrumentation for measuring static strain uses this circuit. [2,5,6,7,8]

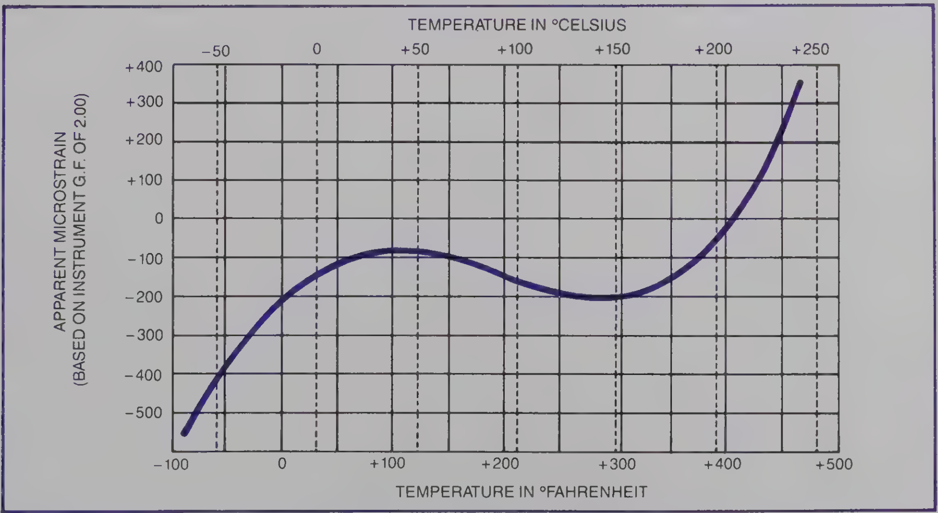


Figure 14: Typical Temperature Induced Apparent Strain

Measurement Methods

Wheatstone Bridge Circuit

Because of its outstanding sensitivity, the Wheatstone bridge circuit (depicted in Figure 15) is the most frequently used circuit for static strain measurements. This section examines this circuit and its application to strain gage measurements. By using a computer in conjunction with the measurement instrumentation, we can simplify using the bridge circuit, increase measurement accuracy, and compile large quantities of data from multichannel systems. The computer also removes the requirement for balancing the bridge, compensates for nonlinearities in output and handles the switching and data storage in multichannel applications.

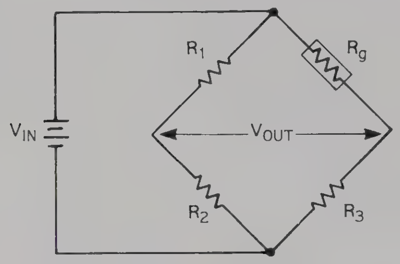


Figure 15: Wheatstone Bridge Circuit

Balanced Bridge Strain Gage Measurement

In Figure 15, V_{IN} is the input voltage to the bridge, R_g is the resistance of the strain gage, R_1, R_2, and R_3 are the resistances of the bridge completion resistors, and V_{OUT} is the bridge output voltage. A ¼ bridge configuration exists when one arm of the bridge is an active gage and the other arms are fixed value resistors or unstrained gages as is the case in this circuit. Ideally the strain gage, R_g, is the only resistor in the circuit that varies, and then only due to a change in strain on the surface of the specimen to which it is attached. V_{OUT} is a function of V_{IN}, R_1, R_2, R_3 and R_g. This relationship is:

$$V_{OUT} = V_{IN}\left[\frac{R_3}{R_3 + R_g} - \frac{R_2}{R_1 + R_2}\right]$$

Equation No. 11

When $(R_1/R_2) = (R_g/R_3)$, V_{OUT} becomes zero and the bridge is balanced. If we could adjust one of the resistor values, R_2 for example, then we could balance the bridge for various values of the other resistors. Figure 16 shows a schematic of this concept.

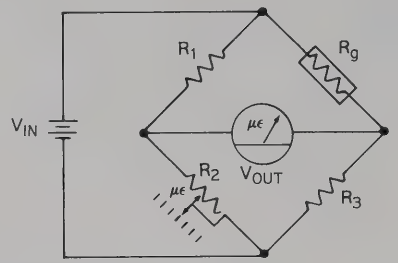


Figure 16: Bridge Circuit with Provision for Balancing the Bridge

Referring to the gage factor equation,

$$GF = \frac{\Delta R/R}{\epsilon}$$

Equation No. 10

we see that the quantity we need to measure is the fractional change in gage resistance from the unstrained value to the strained value. If, when the gage is unstrained, we adjust R_2 until the bridge is balanced and then apply strain to the gage, the change in R_g due to the strain will unbalance the bridge and V_{OUT} will become nonzero. If we adjust the value of R_2 to once again balance the bridge, the amount of the change required in resistance R_2 will equal the change in R_g due to the strain. Some strain indicators work on this principal by incorporating provisions for inputting the gage factor of the gage being used and indicating the change in the variable resistance, R_2, directly in micro-strain.

In the previous example the bridge becomes unbalanced when the strain is applied. V_{OUT} is a measure of this imbalance and is directly related to the change in R_g, the quantity of interest. Instead of rebalancing the bridge we could install an indicator, calibrated in micro-strain, that responds to V_{OUT}. Refer to Figure 16. If the resistance of this indicator is much greater than that of the strain gage, its loading effect on the bridge circuit will be negligible, i.e., negligible current will flow through the indicator. This method often assumes: 1) a linear relationship between V_{OUT} and strain, 2) a bridge that was balanced in the initial, unstrained, state, 3) a known value of V_{IN}. In a bridge circuit the relationship between V_{OUT} and strain is nonlinear but for strains up to a few thousand micro-strain the error is usually small enough to be ignored. At large values of strain, corrections must be applied to the indicated reading to compensate for this nonlinearity.

The majority of commercial strain indicators use some form of balanced bridge for measuring resistance strain gages. In multichannel systems the number of manual adjustments required for balanced bridge methods becomes cumbersome to the user. Multichannel systems, under computer control, eliminate these adjustments by using an unbalanced bridge technique.

Unbalanced Bridge Strain Gage Measurement

The equation for V_{OUT} can be rewritten in the form of the ratio of V_{OUT} to V_{IN}:

$$\frac{V_{OUT}}{V_{IN}} = \left[\frac{R_3}{R_3 + R_g} - \frac{R_2}{R_1 + R_2}\right]$$

Equation No. 12

This equation holds for both the unstrained and the strained condition. Defining the unstrained value of gage resistance as R_g and the change due to strain as ΔR_g, the strained value of gage resistance is $R_g + \Delta R_g$. The actual effective value of resistance in each bridge arm is the sum of all the resistances in that arm and may include such things as lead wires, printed circuit board traces, switch contact resistance, interconnects, etc. As long as these resistances remain unchanged between the strained and unstrained readings, the measurement will be valid. Let's define a new term, V_r, as the difference of the ratios of V_{OUT}

o V_{IN} from the unstrained to the trained state:

$$= \left[\left(\frac{V_{OUT}}{V_{IN}}\right)_{\text{strained}} - \left(\frac{V_{OUT}}{V_{IN}}\right)_{\text{unstrained}}\right]$$

Equation No. 13

By substituting the resistor values that correspond to the two (V_{OUT}/V_{IN}) terms into this equation, we can derive an equation for $\Delta R_g/R_g$. This new equation is:

$$\frac{\Delta R_g}{R_g} = \frac{-4V_r}{1 + 2V_r}$$

Equation No. 14

Note that it was assumed in this derivation that ΔR_g was the only change in resistance from the unstrained to the strained condition. Recalling the equation for gage factor:

$$GF = \frac{\Delta R_g/R_g}{\epsilon}$$

Equation No. 10

and combining these two equations we get an equation for strain in terms of V_r and GF.

$$\epsilon = \frac{-4V_r}{GF(1 + 2V_r)}$$

Equation No. 15

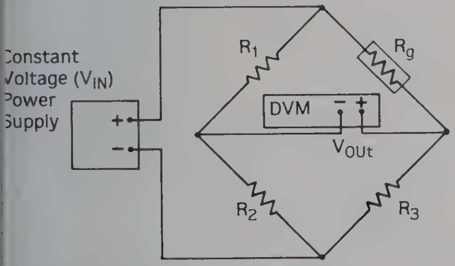


Figure 17: Instrumentation for Unbalanced Bridge Strain Gage Measurement

The schematic in Figure 17 shows how we can instrument the unbalanced bridge.

A constant voltage power supply furnishes V_{IN} and a digital voltmeter (DVM) is used to measure V_{OUT}. The DVM for this application should have a high (greater than 10^9 ohms) input resistance and 1 microvolt or better resolution. The gage factor is supplied by the gage manufacturer. In practice we would use a computer to have the DVM read and store V_{OUT} under unstrained conditions, then take another reading of V_{OUT} after the specimen was strained. Since the values for gage factor and the excitation voltage, V_{IN}, are known, the computer can calculate the strain value indicated by the change in bridge output voltage. If the value of V_{IN} is unknown or subject to variations with time, we can have the DVM measure it at the time V_{OUT} is measured to get a more precise value for V_r. This "timely" measurement of V_{IN} greatly reduces the stability requirements of the power supply, allowing a lower cost unit to be used. Note that in the preceding ¼ bridge example the bridge was not assumed to be balanced nor its output approximated as truly linear. Instead we just derived the equation for strain in terms of quantities that are known, or can be measured, and let the computer solve the equation to obtain the exact strain value.

In the preceding example we made some assumptions that impact the accuracy of the strain measurement:

- resistance in the three inactive bridge arms remained constant from unstrained to strained readings
- DVM accuracy, resolution, and stability were adequate for the required measurement
- resistance change in the active bridge arm was due only to change in strain
- V_{IN} and gage factor were both known quantities

Appendix B shows schematics of several configurations of bridge circuits, using strain gages, and gives the equation for strain as a function of V_r for each.

Multichannel Wheatstone Bridge Measurements

In the preceding example the measurement accuracy was dependent upon the resistances of all the bridge arms remaining constant from the time of the unstrained reading to the time of the strained reading, except for the change in the gage resistance due to strain. If any of the brige arm resistances changed during that time span there would be a corresponding change in bridge output voltage which would be interpreted as strain induced, so we would see an error. The same would be true of any other variation that changed the bridge output voltage. Any switching done in the bridge arms can cause a change in resistance due to variations in the

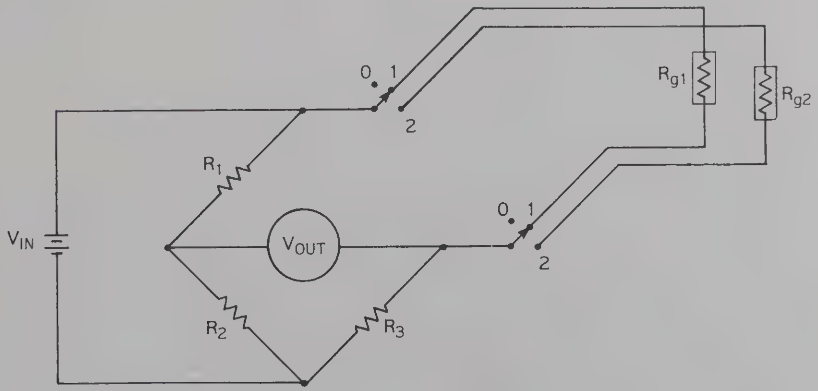


Figure 18: Switching Inside Bridge Arms

Measurement Methods (continued)

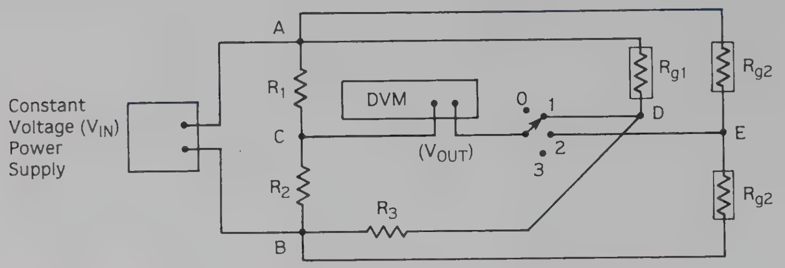


Figure 19: Schematic of Bridge Circuit with Shared Internal Half Bridge and Power Supply

switch or relay contact resistance and affect the bridge output voltage. For that reason it is not desirable to do switching inside the bridge arms for multichannel systems but rather allow those interconnections to be permanently wired and switch the DVM from bridge to bridge. Since a DVM has extremely high input impedance compared to the bridge arms, it doesn't load the bridge and switching the DVM has no effect on the bridge output voltage level. Figures 18 and 19 show schematics of these two methods of switching. We can see that switching inside the bridge arms allows the same bridge completion resistors to be used for multiple gages but that the power to the gage is removed when it is not being read. Also, any variations in switch contact resistance will appear in series with the gage resistance and will be indistinguishable from resistance changes due to strain.

Figure 19 shows a multiple channel arrangement that switches the DVM and also shares the power supply and internal half-bridge. This circuit is known as a "Chevron Bridge" and is often used for strain measurement on rotating machine elements to minimize the number of slip rings. One channel is shown as a ¼ bridge and the other as a ½ bridge (two active gages). The midpoint of the internal half-bridge for either of these configurations serves as a voltage reference point for the DVM and isn't affected by strain. Since the bridge completion resistors must have excellent stability specifications, they are relatively expensive and there is a cost advantage to sharing the internal half bridge in multichannel systems.

For this method to function properly, the circuit must be designed and constructed such that a change in current due to strain in one arm does not change the current in any of the other arms. Also, the excitation voltage, V_{IN}, must be measured across points A-B and it may be desirable to measure this voltage each time a new set of readings is taken from this group of channels. The DVM is switched between points C-D, C-E, etc., to read the output voltages of the various channels in the group. This method keeps all of the gages energized at all times which minimizes dynamic heating and cooling affects in the gages and eliminates the need for switching inside the bridge arms. If the DVM has good low level measurement capability, the power supply voltage can be maintained at a low level thereby keeping the gage self heating effects to a minimum. For example, using a 2 volt power supply for the bridge yields a power dissipation, in a 350 ohm gage, of only 3 milliwatts. Yet even with this low power, 1 micro-strain sensitivity is still maintained with a ¼ bridge configuration (assuming GF=2), when using a DVM with 1 microvolt resolution. Since several channels are dependent upon one power supply and one resistor pair, a failure of one of these components will cause several channels to become inoperative. However the measurement of the excitation voltage permits the power supply to drift, be adjusted, or even replaced with no loss in measurement accuracy.

Four-Wire Ohm Strain Gage Measurement

As we mentioned before, we can measure the change in absolute value of gage resistance to compute strain. This can be done quite accurately using a four-wire ohms measurement technique with a high resolution (e.g., 1 milliohm per least significant digit) digital multimeter (DMM). Figure 20 depicts the four-wire ohms method of resistance measurement. The current source is connected internally in the DMM to the ohms source terminals while the voltmeter is connected to the ohms sense terminals of the DMM. When a measurement is being taken, the current source supplies a known fixed value of direct current through the circuit from the ohms source terminals while the voltmeter measures the d.c. voltage drop across the gage resistance. The absolute resistance value is computed from the values of current and voltage by the DMM and displayed or output to a computer. The lead resistances, R_ℓ, from the ohms source terminals to the gage are in series with the gage resistance but do not affect the accuracy of the measurement, since the voltage is read directly across the gage. The input impedance to the sense terminals is extremely high so the current flow in that loop is negligible. The source current value is typically very low which means the power dissipated in the strain gage is also very low and selfheating effects are virtually eliminated. For example, 1 milliamp is a typical value for the source current and this corresponds

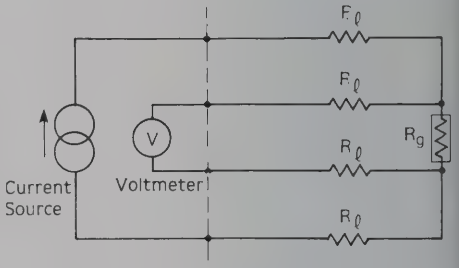


Figure 20: Schematic of Four-wire Ohm Circuit

o a power dissipation of 20 microwatts in a 120 ohm gage or 350 microwatts in a 350 ohm gage.

A technique for voltage offset compensation can be used with four-wire ohms measurements to correct for these effects. This is accomplished by first measuring the voltage across the gage without current flow from the source terminals and subtracting this value from the voltage read with source current flow. The resulting net voltage is then used to compute the gage resistance. Offset compensated four-wire ohms measurements can be made automatically by the DMM if it has that capability or the offset compensation can be accomplished by the computer controlling the instrumentation.

To use four-wire ohms for measuring strain we first make a resistance measurement of the gage in the unstrained condition and store this reading. Then we apply the strain to the specimen and make another measurement of gage resistance. The difference of these two readings divided by the unstrained reading is the fractional change in resistance that we use in the gage factor equation to compute strain. Of course the DMM can input these readings directly to a computer which calculates strain using the gage factor for the particular gage. This technique also lends itself to multichannel systems since variations in switch resistance in the circuit have the same effect as lead resistances and do not affect the accuracy of the measurement.

Constant Current Techniques

In the discussion of bridge circuits we assumed that the bridge excitation was furnished by a constant voltage source. We could have assumed constant current excitation for those discussions and derived the corresponding equations for strain as a function of voltage out and current supplied. In the example of Figure 19 the constant voltage supply which is shared by multiple bridges cannot be directly replaced by a constant current source since we wouldn't know how the current was divided between the various bridge circuits. In some cases the bridge output is more nearly linear when using constant current rather than constant voltage excitation but that is of little consequence if we solve an equation for strain versus output voltage with a computer. The use of a constant current source for a full bridge configuration does eliminate the need to sense the voltage at the bridge which eliminates the need for two wires to the bridge. In general, there is no real measurement advantage to using constant current rather than constant voltage excitation for bridge circuits as applied to strain gage measurements.

The four-wire ohms measurement discussed in the preceding section used a constant current source for excitation and we noted that the lead wires had no affect on the measurement. That method required four wires to be connected to the gage. Constant current excitation is sometimes used with a two-wire gage connection for dynamic strain measurements where temperature drift effects are negligible or can be filtered out from the strain data. In the circuit of Figure 21, changes in gage resistance result in proportional changes in V_{OUT}. Note that V_{OUT} is also affected by changes in the lead resistances, R_ℓ. By measuring only the time varying component of V_{OUT}, the dynamic strain can be observed while the slowly changing effects, such as temperature, are rejected.

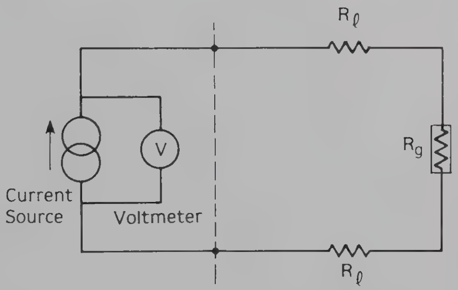


Figure 21: Constant Current Circuit Dynamic Strain Measurement

The use of very sensitive DMMs to measure the bridge imbalance voltage or the gage resistance directly with four-wire ohms limits the speed at which the measurement can be made and only low frequency dynamic strains may be measured with these methods. Higher speed analog to digital converters typically have lower sensitivities so higher signal levels are needed when measuring higher frequency dynamic or transient strains. One way to achieve this is to amplify the bridge output voltage to an acceptable level. Another method is to use a semiconductor strain gage and exploit its large gage factor. A semiconductor gage can be used in a bridge circuit (such as Figure 19) with a DVM having lower resolution and higher speed than that required with metal gages. A semiconductor gage can also be used in a circuit similar to that for four-wire ohms (see Figure 22). In this case, the current source and the DVM should be separate instruments to allow the current level to be adjusted to obtain the best output voltage for the expected maximum strain level.

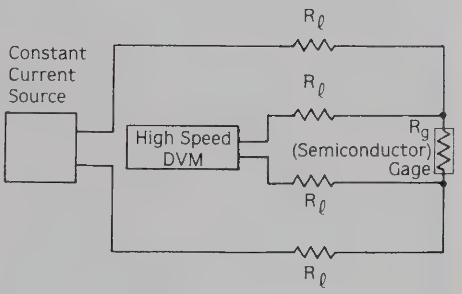


Figure 22: Circuit for Semiconductor Gage and High Speed Digital Voltmeter

The lead wires do not affect the measurement since the voltage, as in four-wire ohms, is measured directly across the gage. This arrangement also allows the use of a less sensitive, higher speed DVM while maintaining reasonable strain resolution. For example, a DVM with 100 microvolt sensitivity gives a strain resolution of 6 $\mu\epsilon$ with a 0.44 milliamp current source (350 ohm semiconductor gage with GF=100).

Practical Strain Measurement

Shielding and Guarding—Interference Rejection

The low output level of a strain gage makes strain measurements susceptible to interference from other sources of electrical energy. Capacitive and magnetic coupling to long cable runs, electrical leakage from the specimen through the gage backing, and differences in grounding potential are but a few of the possible sources of difficulty. The results of this type of electrical interference can range from a negligible reduction in accuracy to rendering the data invalid.

The Noise Model

In Figure 23, the shaded portion includes the Wheatstone bridge strain gage measuring circuit seen previously in Figures 15 and 17. The single active gage R_g shown mounted on a test specimen – e.g., an airplane tail section. The bridge excitation source V_{IN}, bridge completion resistors R_1, R_2 and R_3, and the DVM represent the measurement equipment located a significant distance (e.g., 100 feet) from the test specimen. The strain gage is connected to the measuring equipment via three wires having resistance R_ℓ in each wire. The electrical interference which degrades the strain measurement is coupled into the bridge through a number of parasitic resistance and capacitance elements. In this context, the term "parasitic" implies that the elements are unnecessary to the measurement, are basically unwanted, and are to some extent unavoidable. The parasitic elements result from the fact that lead wires have capacitance to other cables, gages have capacitance to the test specimen, and gage adhesives and wire insulation are not perfect insulators – giving rise to leakage resistance.

Examining the parasitic elements in more detail, the active gage R_g is shown made up of two equal resistors with C_{iso} connected at the center. C_{iso} represents the capacitance between the airplane tail section and the gage foil. Since the capacitance is distributed uniformly along the gage grid length, we approximate the effect as a "lumped" capacitance connected to the gage's midpoint. R_{iso} and C_{iso} determine the degree of electrical isolation from the test specimen which is often electrically grounded or maintained at some "floating" potential different than the gage. Typical values of R_{iso} and C_{iso} are 1000 megohms and 100 pF respectively. Elements C_c and R_c represent the wire-to-wire capacitance and insulation resistance between adjacent power or signal cables in a cable vault or cable bundle. Typical values for C_c and R_c are 30 pF and 10^{12} ohms per foot for dry insulated conductors in close proximity.

The power supply exciting the bridge is characterized by parasitic elements C_{ps} and R_{ps}. A line powered, "floating output" power supply usually has no deliberate electrical connection between the negative output terminal and earth via the third wire of its power cord. However, relatively large amounts of capacitance usually exist between the negative output terminal circuits and the chassis and between the primary and secondary windings of the power transformer. The resistive element R_{ps} is due to imperfect insulators and may be reduced several decades by ionic contamination or moisture due to condensation or high ambient humidity. If the power supply does not feature floating output, R_{ps} may be a fraction of an ohm. It will be shown that use of a non-floating or grounded output power supply drastically increases the mechanisms causing electrical interference in a practical, industrial environment. Typical values for C_{ps} and R_{ps} for floating output, laboratory grade power supplies are 0.01 μf and 100 megohms respectively. It is important to realize that neither the measuring equipment nor the gages have been "grounded" at any point. The entire system is "floating" to the extent allowed by the parasitic elements.

To analyze the sources of electrical interference we must first establish a reference potential. Safety considerations require that the power supply, DVM, bridge completion, etc., cabinets all be connected to earth ground through the third wire of their power cords. In Figure 23 this reference potential is designated as the measurement

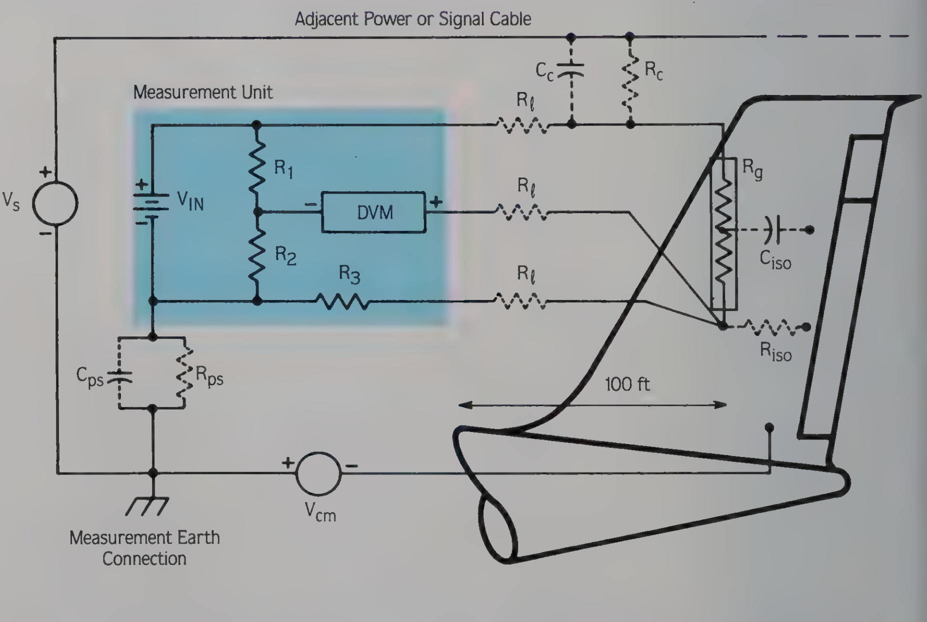


Figure 23: Remote Quarter Bridge Measurement Illustrating Parastic Elements and Interference Sources

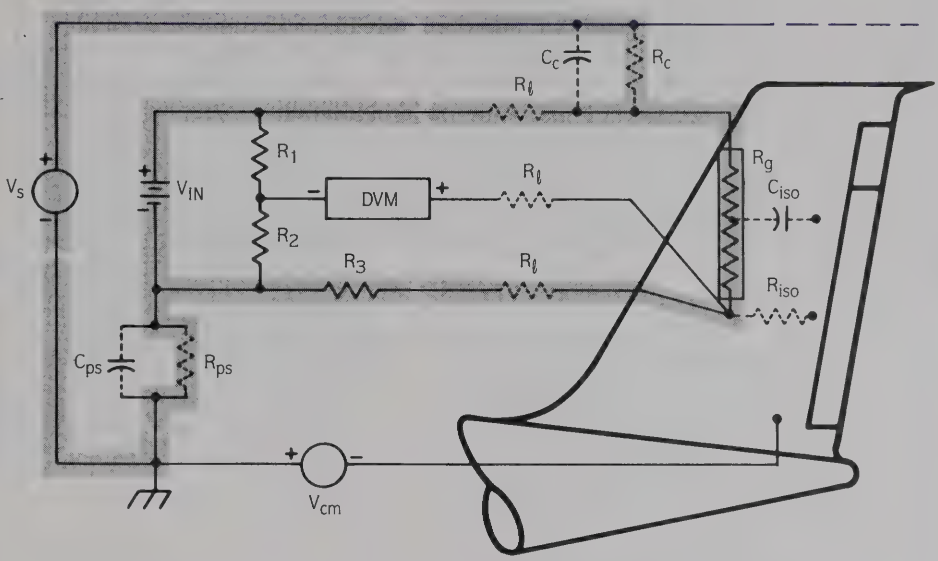


Figure 24: Current Leakage from Adjacent Cable Flows Through Gage Wires Causing Measurement Error

arth connection. The test specimen s often grounded (for safety easons) to the power system at a oint some distance away from the neasurement equipment. This hysical separation often gives rise o different grounding potentials as epresented by the voltage source /cm. In some cases, functional requirements dictate that the test pecimen be "floated" or maintained nany volts away from power ystem ground by electronic power upplies or signal sources. In either ase, V_{cm} may contain dc and time arying components – most often t power line related frequencies. Typical values of V_{cm}, the common node voltage, range from millivolts lue to IR drops in "clean" power ystems to 250 volts for specimens loating at power line potentials, for xample parts of an electric motor. The disturbing source, V_s, is shown onnected to measurement earth nd represents the electrical potenial of some cable in close proximity ut unrelated functionally to the age wires. In many applications, hese adjacent cables may not exist r may be so far removed as to not ffect the measurement. They will e included here to make the analysis general and more complete.

Shielding of Measurement Leads

The need for using shielded measurement leads can be seen by examining the case shown in Figure 24. Here an insulation failure (perhaps due to moisture) has reduced parasitic R_c to a few thousand ohms, and d.c. current is flowing through the gage measurement leads as a result of the source V_s . Negligible current flows through the DVM because of its high impedance. The currents through R_g and R_ℓ develop error-producing IR drops inside the measurement loops.

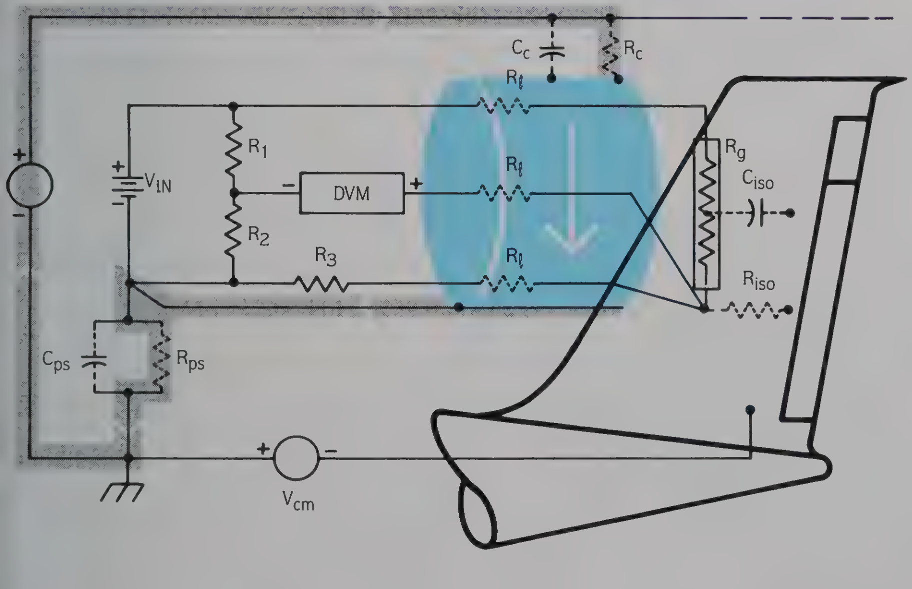


Figure 25: Addition of a Metal Shield Around the Gage Wires Keeps Current Due to V_s Out of Measurement Leads

In Figure 25, a shield surrounds the three measurement leads and the current has been intercepted by the shield and routed to the point where the shield is connected to the bridge. The DVM reading error has been eliminated. Capacitive coupling from the signal cable to unshielded measurement leads will produce similar voltage errors, even if the coupling occurs equally to all three leads. In the case where V_s is a high voltage sine wave power cable, the DVM error will be substantially reduced if the voltmeter integrates the input for a time equal to an integer number of periods (e.g., 1, 10, or 100) of the power line wave form. The exact amount of the error reduction depends upon the DVM's normal mode rejection, which can be as large as 60-140 dB or $10^3:1$ - $10^7:1$ If the DVM is of a type having a very short sampling period, i.e., less than 100 μsec, it will measure the instan-

Practical Strain Measurement (continued)

taneous value of d.c. signal (due to strain) plus interference. Averaging the proper number of readings can reduce the error due to power line or other periodic interference.

In the situation where the measurement leads run through areas of high magnetic fields, near high current power cables, etc., twisted measurement leads minimize the loop areas formed by the bridge arms and the DVM thereby reducing measurement degradation as a result of magnetic induction. The flat, three conductor side-by-side, molded, cable commonly used for strain gage work approaches the effectiveness of a twisted pair by minimizing the loop area between wires. The use of shielded, twisted leads and a DVM which integrates over one or more cycles of the power line wave form should be considered whenever leads are long, traverse a noisy electromagnetic environment, or when highest accuracy is required.

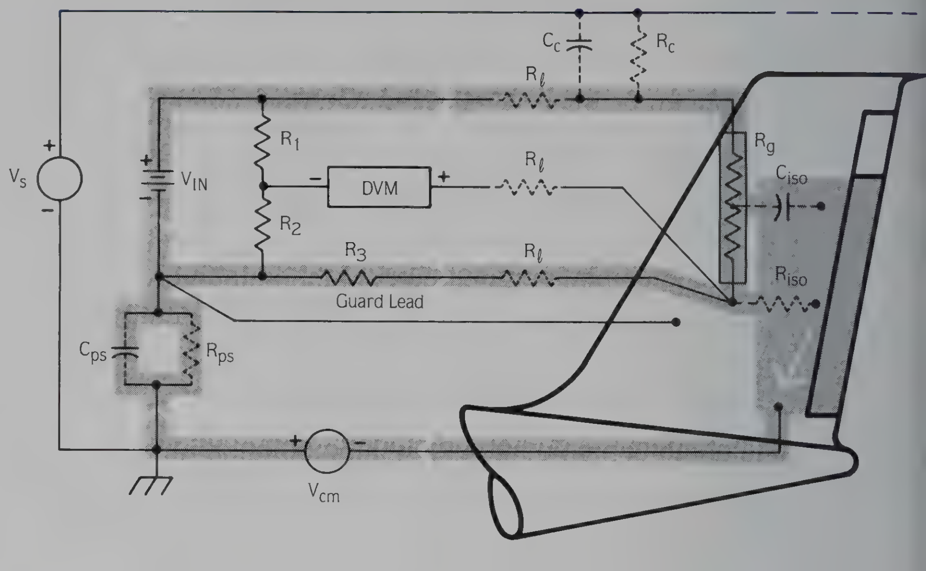


Figure 26: Error-producing Common Mode Current Path

Guarding the Measuring Equipment

Figure 26 shows the error-producing current paths due to the common mode source, V_{cm}, entering the measurement loop via the gage parasitic elements, C_{iso} and R_{iso}. In the general case, both a.c. and d.c. components must be considered. Again current flow through gage and lead resistances result in error voltages inside the bridge arms. Tracing either loop from the DVM's negative terminal to the positive terminal will reveal unwanted voltages of the same polarity in each loop. The symmetry of the bridge structure in no way provides cancellation of the effects due to current entering at the gage.

Whereas shielding kept error-producing currents out of the measurement loop by intercepting the current, guarding controls current flow by exploiting the fact that no current will flow through an electrical component having both of its terminals at the same potential.

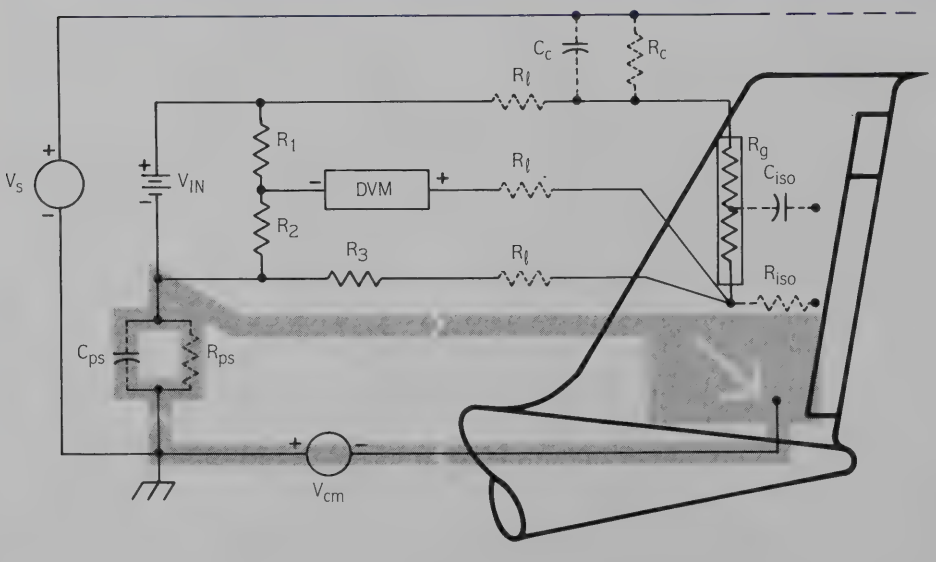


Figure 27: Guard Wire Diverts Common Mode Current Away from Gage Wires

In Figure 27, a "guard" lead has been connected between the test specimen (in close proximity to the gage) and the negative terminal of the power supply. This connection forces the floating power supply and all the measuring equipment – including the gage – to the same electrical potential as the test specimen. Since the gage and the specimen are at the same potential, no error producing current flows through R_{iso} and C_{iso} into the measuring loops. Another way of interpreting the result is to say that the guard lead provides an alternate current path around the measuring circuit. It should be observed that if the power supply and the rest of the measuring circuits could not float above earth or chassis potential, the guarding technique would reduce the interference by factors of only 2:1 or 4:1. Proper guarding with a floating upply should yield improvements n the order of 10^5:1 or 100 dB.

In situations where it is possible to round the test specimen at measrement earth potential, the comnon mode source, V_{cm}, will be ssentially eliminated.

xtension to Multichannel Measurements

Figure 28, on the following page, hows the extension of the guarding echnique to a multi-channel strain age measurement using a shared ower supply and internal half bridge ompletion resistors. For simplicity, nly the capacitive parasitic elements re shown. In ordinary practice, apacitive coupling is usually more ignificant and more difficult to avoid han resistive coupling. For generaliy we've used two test specimens at ifferent potentials with respect to easurement earth. The switching hown in the figure allows simulaneous selection of the DVM and the ssociated guard connection.

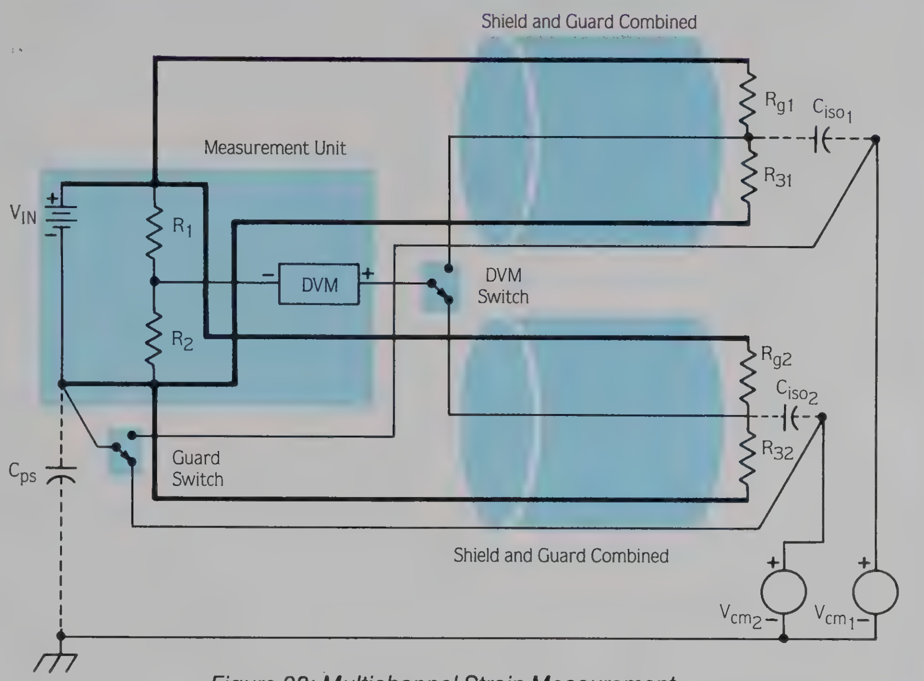


Figure 28: Multichannel Strain Measurement Including Two Separate Test Specimens

Figure 29 illustrates the currents lowing due to the specimen potenials V_{cm1} and V_{cm2} . Note that egardless which channel is selected, the guard line (also functioning as the shield for the wires to the gage) keeps the common mode current out of the gage leads selected for the measurement. Common mode current flows harmlessly through the gage leads of the unselected channel. It should be noted that each lead wire shield is "grounded" at only a single point. The common mode current through each combined guard and shield is limited by the relatively high impedance of the parasitic element C_{ps} and should not be confused with the "heavy" shield current which might occur if a shield were grounded at both ends, creating a "ground loop".

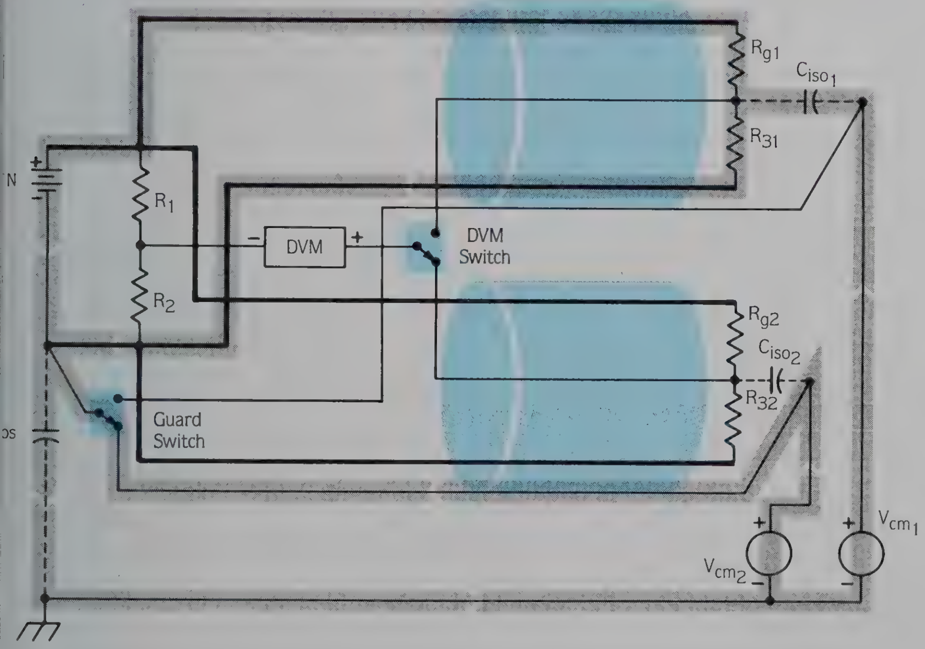


Figure 29: Multichannel Guard Switching Keeps Common Mode Current Out of Selected Gage Leads

CMR Limitations

The schematics and discussion of guarding presented thus far might convey the impression that infinite rejection of common mode interference is possible. It seems reasonable to ask what if anything limits common mode rejection? Figure 30 includes a new parasitic element, C_{ug}, the unguarded capacitance to chassis associated with the DVM and multiplexer. In practice, the DVM and multiplexer are usually realized as guarded instruments [Reference 13] featuring three wire switching

Practical Strain Measurement (continued)

and measurements, but the guard isolation is not perfect. Capacitance ranging from 15 pF – 20 μf can be found between the instrument low connection and chassis. In Figure 30, this capacitance causes a portion of the common mode current in the selected channel to flow through the internal half bridge resistors R_1 and R_2 giving rise to a measurement error. In a multichannel system, all of the unselected channels (gages) sharing the same power supply also contribute current, but this current exits the bridge via the power supply and returns through the guard wire causing no additional errors.

In Figure 30, the a.c. interference voltage presented to the terminals of the DVM causes an error because the d.c. measuring voltmeter does not totally reject the a.c. A DVM's ability to measure d.c. voltage in the presence of a.c. interference is called the normal mode rejection ratio NMRR and is usually stated for 50 and 60 Hz interference.

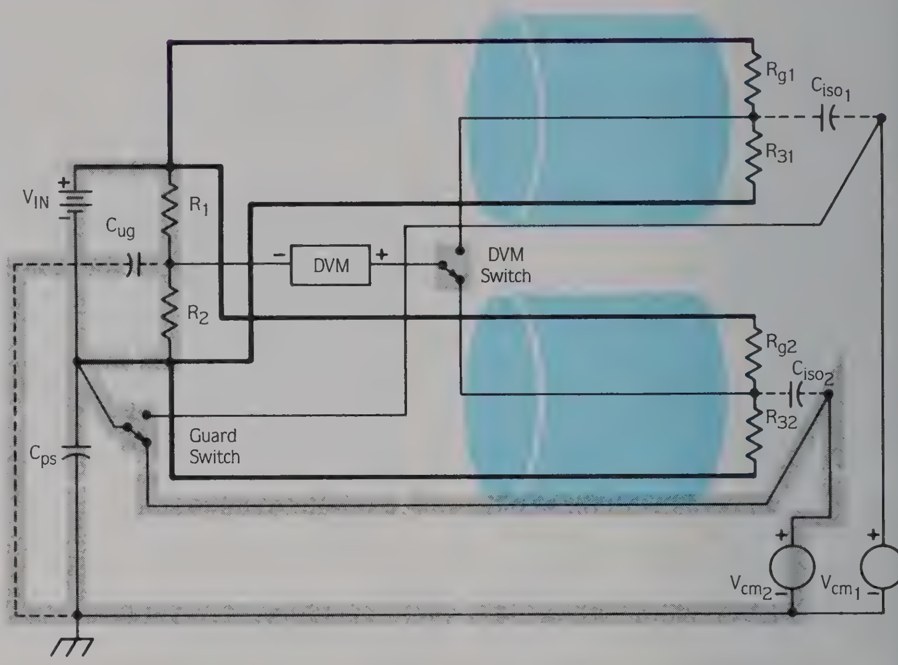


Figure 30: Unguarded Capacitance of Multiplexer and DVM Result in Measurement Error Due to V_{cm2} of Selected Channel

$$\text{NMRR} = 20 \log \frac{V_{NM}\text{ (a.c.)}}{V_{DVM}\text{ (d.c.)}}$$

Equation No. 16

A d.c. voltmeter's NMRR is a function of input filtering and the analog to digital conversion technique employed.

Additionally, the DVM and multiplexer system reject a.c. interference via guarding and design control of parasitics. The quantitative measure of a system's ability to reject common mode a.c. voltage is the common mode rejection ratio, CMRR, defined as:

$$\text{CMRR} = 20 \log \frac{V_{cm}\text{ (a.c.)}}{V_{DVM}\text{ (a.c.)}}$$

Equation No. 17

where V_{cm} and V_{DVM} are both sinusoids at the power line frequency of interest – 50, 60, or 400 Hz. Note that V_{DVM} is an a.c. wave form presented to the terminals of a d.c. voltmeter. Thus CMRR is an a.c. voltage transfer ratio from the common mode source to the DVM terminals. Caution must be exercised in comparing CMRR specifications to insure that identical procedures were employed in arriving at the numerical result.

The overall figure of merit for a measurement system is the effective common mode rejection ratio ECMRR and reflects the system's ability to measure d.c. voltage (strain) in the presence of a.c. common mode interference. If all measurements are made at the same frequency,

$$\text{ECMRR} = \text{CMRR} \times \text{NMRR}$$
$$\frac{\text{a.c. interference}}{\text{d.c. response error}} = \underbrace{\frac{\text{a.c. interference}}{\text{a.c. @DVM}}}_{\substack{\text{transmission}\\ \text{via parasitics}\\ \text{and guarding}}} \times \underbrace{\frac{\text{a.c. @DVM}}{\text{d.c. response error}}}_{\substack{\text{d.c. voltmeter}\\ \text{response to}\\ \text{a.c. input}}}$$

Equation No. 18

and if the rejection ratios are expressed in dB,

$$\text{ECMRR(dB)} = \text{CMRR(dB)} + \text{NMRR(dB)}$$

Equation No. 19

Thus ECMRR describes how well the parasitics are controlled in the system and the sampling characteristics of the DVM, i.e., integrating or instantaneous sampling.

Reference 10 provides additional information on the subject of floating, guarded measurements and rejection ratios. Appendix E contains measurement sensitivity data which can be used to compute measurement error (in $\mu\epsilon$) as a function of DVM, power supply, and bridge completion resistor specifications.

Bridge Excitation Level

The bridge excitation voltage level affects both the output sensitivity and the gage self heating. From the measurement standpoint a high extation level is desirable but a lower vel reduces gage self heating. The ectrical power in the gage is ssipated as heat which must be ansferred from the gage to the urroundings. In order for this heat ansfer to occur the gage temper-ture must rise above that of the pecimen and the air. The gage mperature is therefore a function f the ambient temperature and the mperature rise due to power dissi-ation.

An excessive gage temperature an cause various problems. The car-er and adhesive materials are no nger able to faithfully transmit the train from the specimen to the grid the temperature becomes too igh. This adversely affects hyste-esis and creep and may show up as stability under load. Zero or nstrained stability is also affected y high gage temperatures. Temper-ture compensated gages suffer a ss of compensation when the mperature difference between he gage grid and the specimen ecomes too large. When the gage is ounted on plastics, excessive ower dissipation can elevate the mperature of the specimen under he gage to the point that the aterial properties of the specimen hange.

The power that must be dissi-ated as heat by the gage in a bridge rcuit with equal resistance arms is iven by the following equation:

$$P = V^2/4R_g = (I^2)R_g$$

Equation No. 20

where P is the power in watts, R_g is the gage resistance, I is the current through the gage and V is the bridge excitation voltage. From equation (20) we see that lowering the excitation voltage (or gage current) or increasing the gage resistance will decrease the power dissipation. When self-heating may be a problem, higher values of gage resistance should be used. Table 3 illustrates the relationship between voltage, gage resistance and power dissipation.

The temperature rise of the grid is difficult to calculate because many factors influence the heat balance. Unless the gage is submerged in a liquid, most of the heat transfer will occur by conduction to the specimen. Generally, cooling of the gage by convection is undesirable because of the possibility of creating time variant thermal gradients on the gage. These gradients can generate voltages due to the thermocouple effect at the lead wire junctions causing errors in the bridge output voltage. Heat transfer from the gage grid to the specimen is via conduction. Therefore the grid surface area and the materials and thicknesses of the carrier and adhesive influence gage temperature. The heat sink characteristics of the specimen are also important.

POWER DENSITY is a parameter used to evaluate a particular gage size and excitation voltage level for a particular application. Power density is the power dissipated by the gage divided by the gage grid area and has units of watts/in.^{2}. Recommended values of power density vary, depending upon accuracy requirements, from 2-10 for good heat sinks, such as heavy aluminum or copper sections, to 0.01-0.05 for poor heat sinks such as unfilled plastics. Stacked rosettes create a special problem in that the temperature rise of the bottom gage adds to the two gages above it and that of the center gage adds to the top gage. These may require a very low voltage or different voltages for each of the three gages to have the same temperature at each gage. [6]

One way we can determine the maximum excitation voltage that can be tolerated is by increasing the voltage until a noticeable zero instability occurs. We then reduce the voltage until the zero is once more stable and without a significant offset relative to the zero point at a low voltage. The bridge completion resistors also dissipate power and in practice may be more susceptible to drift from self heating effects than the strain gage. The stability of the bridge completion resistors is related to load-life, and maintaining only a fraction of rated power in them will give better long term stability. If the above method of finding the maximum voltage level is used, care should be exercised to insure that the power rating of the completion resistors is not exceeded as the voltage is increased.

Reducing the bridge excitation voltage dramatically reduces gage power, since power is proportional to the square of voltage. However, bridge output voltage is proportional to excitation voltage, so reducing it lowers sensitivity. If the DVM used to read the output voltage has 1 microvolt resolution, 1 micro-strain resolution can be maintained, with a ¼ bridge configuration, using a 2 volt bridge excitation level. If the

STRAIN GAGE POWER DISSIPATION

Bridge Excitation Voltage	Gage Power in Milliwatts			
	1000 Ohm	500 Ohm	350 Ohm	120 Ohm
0.1	0.0025	0.005	0.007	0.021
0.2	0.010	0.020	0.029	0.083
0.5	0.0625	0.125	0.179	0.521
1.0	0.250	0.500	0.714	2.083
2.0	1.000	2.000	2.857	8.333
3.0	2.250	4.500	6.429	18.750
4.0	4.000	8.000	11.429	33.333
5.0	6.250	12.500	17.857	52.083
10.0	25.000	50.000	71.400	208.300

Table 3

Practical Strain Measurement (continued)

DVM has 0.1 microvolt resolution the excitation voltage can be lowered to 0.2 volts while maintaining the same strain resolution. From Table 3 we see that, at these excitation levels, the power dissipated by a 350 ohm gage goes from 2.857 to 0.029 milliwatts. So, using a sensitive DVM for measuring the bridge output permits the use of low excitation voltages and low gage self heating while maintaining good measurement resolution.

The four-wire ohms technique is also a good way to keep the power in the gage extremely low. This is due to the low value of constant current supplied to the gage by the DMM, typically 1 milliamp. This current (1 milliamp) corresponds to a power dissipation of 0.12 milliwatts in a 120 ohm gage and 0.35 milliwatts in a 350 ohm gage. With four-wire ohms a gage is energized only when it is selected and is actually being measured by the DMM. As mentioned previously, resolution will be lower using four-wire ohms than with a bridge, but will be adequate for many applications.

Lead Wire Effects

In the preceding chapter reference was made to the effects of lead wire resistance on the strain measurement for the various configurations. In a bridge circuit the lead wire resistance can cause two types of errors. One error is due to resistance changes in the lead wires that are indistinguishable from resistance changes in the gage. The other error is known as LEAD WIRE DESENSITIZATION and becomes significiant when the magnitude of the lead wire resistance exceeds 0.1% of the nominal gage resistance. The significance of this source of error is shown in Table 4.

LEAD WIRE DESENSITIZATION
(Refer to Figure 32)

¼ and ½ bridge, 3-wire connections

AWG	R_g=120 Ohms	R_g=350 Ohms
18	.54%	.19%
20	.87	.30
22	1.38	.47
24	2.18	.75
26	3.47	1.19
28	5.52	1.89
30	8.77	3.01

Magnitudes of computed strain values will be low by the above percent per 100 feet of hard drawn solid copper lead wire at 25°C (77°F)

Table 4

If the resistance of the lead wires is known, the computed values of strain can be corrected for LEAD WIRE DESENSITIZATION. In a prior section, we developed equations for strain as a function of the measured voltages for a ¼ bridge configuration:

$$\Delta R_g/R_g = -4V_r/(1 + 2V_r)$$

Equation No. 14

$$\epsilon = -4V_r/GF(1+2V_r)$$

Equation No. 15

These equations are based on the assumptions that V_r is due solely to the change in gage resistance, ΔR_g, and that the total resistance of the arm of the bridge that contained the gage was R_g. Referring to Figure 32 we see that one of the lead wire resistances, R_ℓ, is in series with the gage so the total resistance of that bridge arm is actually $R_g + R_\ell$. If we substitute this into equation 14 it becomes:

$$\frac{\Delta R_g}{R_g} = \left(\frac{-4V_r}{1+2V_r}\right)\left(\frac{R_g+R_\ell}{R_g}\right)$$

Equation No. 21

Rewriting the equation for strain we see that the previous strain equation is in error by a factor of the ratio of the lead wire resistance to the nominal gage resistance.

$$\epsilon = \frac{-4V_r}{GF(1+2V_r)} \bullet \underbrace{\left(1 + \frac{R_\ell}{R_g}\right)}_{\text{Error Term}}$$

Equation No. 22

This factor is lead wire desensitization and we see from equation (22) and from Table 4 that the effect is reduced if the lead wire resistance is small and/or the nominal gage resistance is large. If ignoring this term $(1 + R_\ell/R_g)$ will cause an unacceptable error then it should be added to the computer program such that the strains computed with equation 15 are multiplied by this factor. Appendix B gives the equations for various bridge configurations and the lead wire resistance compensation terms that apply to them. Appendix A has a table containing the resistance, at room temperature, of some commonly used sizes of copper wire.

The most common cause of

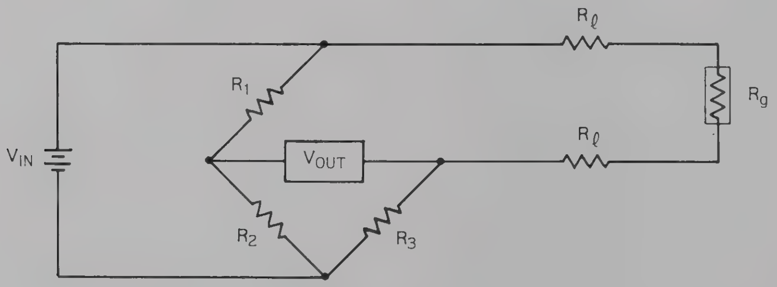


Figure 31: Two-wire ¼ Bridge Connection

changes in lead wire resistance is temperature changes. The copper used for lead wires has a nominal temperature coefficient of resistance, at 25°C, of 0.00385 ohms/ohm °C. For the 2-wire circuit in Figure 31, this effect will cause an error if the temperature during the unstrained reading is different than the temperature during the strained reading. An error occurs because any change in resistance in the gage arm of the bridge during this time is assumed to be due to strain. Also, both lead wire resistances are in series with the gage in the bridge arm further contributing to the lead wire desensitization error.

The THREE-WIRE method of connecting the gage, shown in Figure 32, is the preferred method of wiring strain gages to a bridge circuit. This method compensates for the effect of temperature on the lead wires. For effective compensation the lead wires must have approximately the same nominal resistance, the same temperature coefficient of resistance and be maintained at the same temperature. In practice this is effected by using the same size and length wires and keeping them physically close together.

Temperature compensation is accomplished because the resistance changes occur equally in adjacent arms of the bridge and therefore the net effect on the output voltage of the bridge is negligible. This technique works equally well for ¼ and ½ bridge configurations. The lead wire desensitization effect is reduced over the two-wire connection because only one lead wire resistance is in series with the gage. The resistance of the signal wire to the DVM doesn't affect the measurement because the current flow in this lead is negligible due to the high input impedance of the DVM.

Mathematical correction for lead wire desensitization requires the resistances of the lead wires to be known. The values given in wire tables can be used, but for temperature extremes, measurement of the wires after installation is required for utmost accuracy. Two methods for arriving at the resistance of the lead wires from the instrumentation side of the circuit in Figure 32 follow:

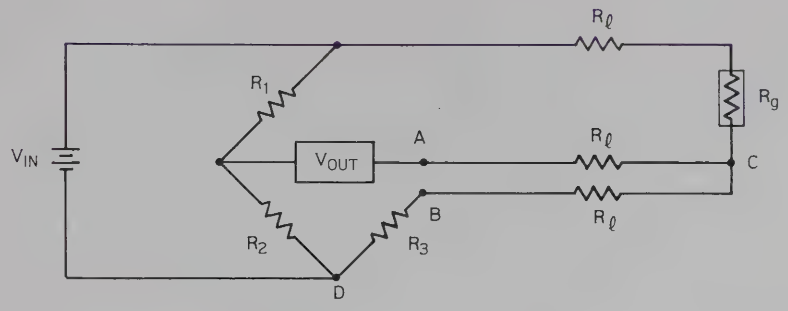


Figure 32: Three-wire ¼ Bridge Connection

(1) If the three wires are the same size and length, the resistance measured between points A and B, before the wires are connected to the instrumentation, is $2R_\ell$.

(2) Measure the voltage from A-B (which is equivalent to B-C) and the voltage from B-D. Since R_3 is typically a precision resistor whose value is well known, the current in the C-D leg can be computed using ohms law. This is the current that flows through the lead resistance so the value of R_ℓ can be computed, since the voltage from B-C is known. The equation for computing R_ℓ is:

$$R_\ell = \frac{V_{AB}}{V_{BD}} \bullet R_3$$

Equation No. 23

These measured values for lead resistance should be retained for later calculations.

Diagnostics

To insure strain data that is as error free as possible, various diagnostic checks can be performed on the gage installation and instrumentation. In a stress analysis application the entire gage installation can't be calibrated as can be done with certain transducers. Therefore potential error sources should be examined prior to taking data.

Mounted Gage Resistance

The unstrained resistance of the gage should be measured after the gage is mounted but before the wiring is connected to the instrumentation. This test will help locate gages damaged during installation. Under laboratory conditions with room temperature cure adhesives, the mounted resistance value of metal foil gages should usually fall within the package tolerance range for the gage. Under field conditions the shift in gage resistance will usually be less than 2%. Greater shifts may indicate damage to the gage. The farther the gage resistance value deviates from the nominal value, the larger the unstrained bridge output voltage. This limits the strain range at maximum resolution when using the unbalanced bridge technique. The easiest, accurate way to measure this resistance is with the four-wire ohms function of a DMM.

Gage Isolation

The isolation resistance from the gage grid to specimen, if the specimen is conductive, should also be measured before connecting the lead wires to the instrumentation. This check should not be made with a high-voltage insulation tester, because of possible damage to the

Practical Strain Measurement (continued)

gage, but rather with an ohmmeter. A value of isolation resistance of less than 500 megohms usually indicates the presence of some type of surface contamination. Contamination often shows up as a time varying high resistance shunt across the gage which causes an error in the strain measurement. For this reason an isolation resistance value of at least 150 megohms should be maintained. A properly mounted gage with fully cured adhesive will usually have 1000 megohms or higher isolation resistance so any gages with low values should be suspect.[2]

Diagnostic Bridge Measurements

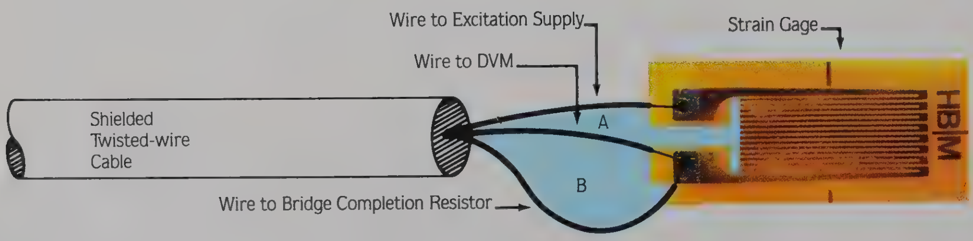
Additional errors occur when voltages are induced in the measurement circuit by sources other than strain. These voltages may be in the form of static offsets such as a thermally induced voltage or time varying disturbances such as a magnettically induced voltage. Other sources of interference are capacitive coupling of signals to the gage or wiring, resistive leakage paths to the gage or from the wiring to adjacent signal carriers, a leakage path in the excitation supply, a poor connection to guard or a damaged shield. Since error producing interference can arise from so many unexpected sources, what can be done to detect the presence of unwanted voltages?

The first step is to disconnect the excitation supply from the bridge and power up all equipment that is to be operating during the test. This insures that all the interference sources are activated. Next, take several consecutive bridge output voltage readings for each strain gage channel. The voltages should be very nearly zero. If there is an offset voltage it could be thermally induced or due to a resistive leakage path. A time varying cyclic voltage could be caused by resistive, magnetic or capacitive coupling to the interfering source. Erratic voltage readings could be due to an open input to the DVM. An integrating voltmeter which samples over an integer number of power line cycles greatly increases rejection of magnetic induction and other interference sources at power line frequency. When using non-integrating voltmeters several readings can be averaged to minimize the effect on static strain readings.

Thermally induced voltages are caused by thermocouple effects at the junctions of dissimilar metals within the measurement circuits, in the presence of temperature gradients. These may occur at connectors, where the lead wire meets the gage metal, in switches or in the DVM. Magnetically induced voltages occur when the wiring is located in a time varying magnetic field. Magnetic induction can be controlled by using twisted lead wires and forming minimum but equal loop areas in each side of the bridge. These loops should be arranged as shown in Figure 33 to have minimum effect on bridge output. In severe magnetic fields, magnetic shielding for the wiring may be required.

The next step is to connect the excitation supply to the bridge. A series of readings taken by the DVM of the excitation voltage is a good verification that the excitation supply is set to the correct voltage level and is stable enough to allow the accuracy expected. Some thermally induced voltages may be due to heating effects from power dissipated in the bridge circuit so a check should be made with the power applied. This is done by taking a sequence of readings of the bridge output then reversing the polarity of the excitation supply and repeating the sequence. One half the difference in the absolute values of the bridge output voltages is the thermally induced voltage. If the temperature and power levels will remain at this level during the test then subsequent voltage readings could be corrected, by this offset voltage amount. To monitor the thermally induced voltages the bridge power can be connected with switches so that the voltage readings may be taken with both power supply polarities. If the measured thermally induced voltages are more than a few microvolts the source should be found and eliminated rather than trying to correct the voltage readings. If, after a reasonable time for the gage and bridge resistors to reach steady state temperatures, the voltage is still drifting the excitation level may be too high.

Figure 34: Typical Installation



Minimize Areas A and B (Shaded)
and Make Them Equal
Quarter Bridge Three-Wire Connection

Figure 33: Gage Wiring to Minimize Magnetic Induction

Another test on the gage, particularly on the gage bond, can be

performed at this time. While monitoring the bridge output with the DVM, press lightly on the strain gage with a pencil eraser. The output voltage should change slightly but then return to the original value when the pressure is removed. If the output voltage doesn't return to the original value or becomes erratic the gage is probably imperfectly bonded or is damaged and should be replaced.

The unstrained bridge output voltage level also has diagnostic value. A shorted or open gage will give an output of approximately one half the excitation voltage. In many cases the unstrained bridge output should be 2 millivolts or less per excitation volt. For example, if each of the four bridge arms had a tolerance of ±1% the unstrained output would at most be, 10 millivolts per excitation volt. So, if the unstrained output is more than a few millivolts per volt of excitation the installation should be inspected. If the test entails some type of temperature cycle and a temperature compensated gage is utilized, recording the unstrained output over the temperature cycle is a method of verifying the adequacy of the compensation.

Shunt Calibration (Verification)

When using the unbalanced bridge method of strain measurement with instrumentation under computer control, there are no adjustments for bridge balance or span. Since shunt calibration was originally used to adjust the span of balanced bridge instruments, what is the role of shunt calibration with an imbalanced bridge? Shunt calibration with this technique might more correctly be termed "shunt verification" since the instrumentation won't actually be calibrated by shunt calibration. Shunt verification is the placing in parallel with one of the bridge arm resistors, or gages, a resistor of known value. This will change the bridge output voltage a predictable amount and if we measure this output change, just as if it were caused by strain, we can compute the equivalent strain value. Since we already know the change in resistance from the parallel combination of resistors, we can compute the equivalent strain value for a given gage factor, i.e., $\epsilon = \mathbf{(1/GF)(\Delta R/R)}$. By using the same program subroutines and instrumentation which will be used in the actual test, we verify most of the system and gain confidence in the test setup.

The value of the shunt resistor is often in the 10-500 kilohm range so the current through it is low: less than 1 milliamp. This resistor is also outside the bridge arms so the effects of switching and lead wires are not as important as for the gage. Any of the bridge arms for any bridge configuration may be shunted and a corresponding value of equivalent strain computed.

Temperature Effects

We have examined ways to compensate for the effects of temperature on the lead wires to the gage. Now let's look at some methods to compensate for the temperature effects on gage resistance and gage factor. Some of these methods require the temperature to be measured at the gage. This can be accomplished by several different temperature sensors such as thermocouples, thermistors, and resistance temperature detectors (RTDs). Since we want to sense the temperature of the strain gage itself, problems can arise when large thermal gradients exist or when the temperature is rapidly changing. We need a sensor that has adequate thermal response and need to locate it such that it senses the same temperature that exists at the gage.

Gage Factor versus Temperature

The gage manufacturer supplies a nominal gage factor and tolerance with each gage. If this gage factor is per NAS 942, Reference [9], it is the nominal gage factor and tolerance as measured at room temperature, in a uniaxial stress field, on a material with a Poisson's ratio of 0.285, for that particular lot of gages. The

Practical Strain Measurement (continued)

tolerance on the gage factor directly affects the accuracy of the strain computation, in other words, the computed strain value will have a tolerance at least as great as the gage factor tolerance. A plot showing how gage factor varies with temperature is also furnished with the gage. This plot is in the form of % gage factor variation (%ΔGF) versus temperature (T). The temperature at which these variations become significant depends upon the gage alloy and the accuracy required.

In practice the temperature must be measured at the gage during the strained measurement and the gage factor variation computed or "looked up". The actual gage factor is then computed using this variation and the nominal gage factor,

$$GF_A = GF\,\frac{(1 + \%\,\Delta GF)}{100}$$

Equation No. 24

This actual gage factor, GF_A, is then used in the equation for computing strain, e.g., equation 15, instead of GF. The value of strain thus computed is compensated for the effect of temperature on the gage factor.

For most metallic gage alloys, commonly used for static strain measurement, the gage factor variation with temperature is nearly linear over a broad temperature range and is less than ±1% for temperature excursions of ±100°C. For example, the equation for gage factor variation versus temperature in °C for a typical temperature compensated constantan alloy gage, as taken from the plot enclosed by the manufacturer, was found to be: $\%\Delta GF = 0.007T - 0.1$. For gage alloys with nonlinear characteristics, we need to use a point by point correction or some type of curve fitting routine to approximate the temperature dependence. In general, gage factor temperature compensation is required only for large temperature extremes or for tests requiring the utmost accuracy.

Temperature Induced Apparent Strain

For temperature compensated strain gages, the manufacturer supplies a plot of temperature-induced APPARENT STRAIN versus temperature. This plot is obtained by installing a sample of gages from the lot on a piece of unstrained material having a thermal coefficient of expansion matching that for which the compensated gage was intended, and varying the temperature. The apparent strain value is then computed and plotted versus temperature. The apparent strain curve may have been plotted by using a gage factor of +2. This should be considered when using this plot since the actual gage value may be different and temperature dependent. A fourth- or fifth-order polynominal may be used to describe the apparent strain curve and can be obtained from the manufacturer or derived from the plot. Thermally-induced apparent strain occurs because perfect temperature compensation over a broad range can't be achieved. It results from the interaction of the thermal coefficient of resistance of the gage and the differential thermal expansion between the gage and the specimen. Also, the specimen will seldom be the exact alloy used by the gage manufacturer in determining the apparent strain curve. Apparent strain is, of course, zero for the temperature at which the gage is mounted. If that temperature were maintained for the duration of the test no correction would be required, but if the temperature varies during the course of the test, compensation for the apparent strain may be required depending upon the temperature changes, the gage alloy and the accuracy required.

If the temperature changes between the time of the unstrained and strained readings, errors may be incurred as can be seen from the apparent strain plot. These errors are in the form of a strain offset. If the gage temperature and the apparent strain characteristics are known, this offset can be calculated and the strain value compensated accordingly. Another way of achieving compensation is to use an unstrained "dummy" gage mounted on the same material and subjected to the same temperature as the active gage. This dummy gage and the active gages that are to be compensated should all be from the same manufacturer's lot so they all have the same apparent strain characteristics. The dummy can be used in a bridge arm adjacent to the active gage thereby effecting electrical cancellation of the apparent strain. For multichannel systems where many gages are mounted in an area of uniform temperature, it is more efficient to read the dummy gage directly. The value of strain read from the dummy gage will be the value of the apparent strain. The strain readings from the active gages that are mounted on the same material, at the same temperature, can then be corrected by subtracting this amount from them.

There are some cases where it is desirable to generate a thermally induced apparent strain curve for the particular gage mounted on the test specimen. Such would be the case if a compensated gage weren't available to match the thermal coefficient of expansion of the specimen material or if the compensation weren't adequate for the desired accuracy. Any time the temperature varies during the test the accuracy of the apparent strain compensation can be improved by using the actual characteristics of the mounted gage. To accomplish this the mounted but mechanically unstrained gage must be subjected to temperature variations and the apparent strain computed at appropriate values of measured temperature. With computer controlled instrumentation, the data can be taken automatically while the temperature is varied. If the temperatures of the actual test are known, the apparent strain values can be recorded at only those temperatures and used as a "look up" table for correction of the test data. The temperature compensated gage factor of the mounted gage should be used for computing these apparent strain values. If the test temperatures at which data will be taken are not known, then it will be necessary to generate the equation for the apparent strain curve over the temperature range of interest. Curve-fitting computer programs are available to generate an equation that approximates the measured characteristics. [5,6]

Data: Input, Output, Storage

When using unbalanced bridge techniques with computer control, data storage becomes an important consideration. Storage of the unstrained bridge imbalance voltage ratio is especially critical since for some tests it may be impossible to return to the unstrained condition. This unstrained data should be stored in nonvolatile media such as magnetic tape or disc with a redundant copy if the test is critical or of long duration. Storage of the subsequent strained readings may be done during or after the test as required for data reduction or archival purposes. Large amounts of data can be stored quickly and inexpensively with the media available today, and frequent storage of data is good insurance against power interruptions and equipment failures.

Previously we discussed using one power supply for several different channels of strain gages and measuring it with an accurate DVM. This enables us to use an inexpensive supply and also allows its replacement should it fail, with no loss in measurement accuracy. We also discussed a circuit that used a common internal half-bridge for several channels of strain gages. For very expensive and/or long term tests when using this technique it may be desirable to have some type of "backup" for this resistor pair since several data channels will be lost should a resistor fail. This can be accomplished by reading the voltage across each of the two resistors and the power supply voltage, and storing these voltages in a nonvolatile medium. Should the resistor pair fail, it would be replaced with a new pair and a new set of voltage readings taken. These two sets of readings would then be used to compute an offset voltage to compensate for the difference in the ratio of the two pairs of resistors. This offset voltage would be added to all strained imbalance voltage readings taken with the new pair of resistors. This technique can result in as little as ± 10 micro-strain loss in measurement accuracy.

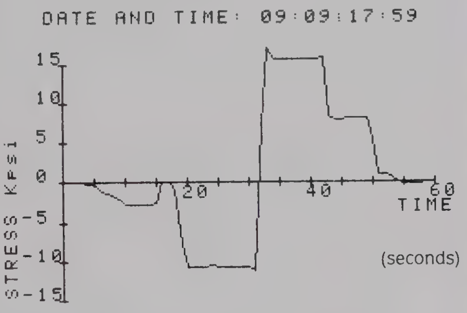
```
UNSTRAINED RAW DATA
CHAN    Vout          Vin       Ratio
 0   -0.000589     1.980   -0.000298
 1    0.000528     1.980    0.000267
 2    0.000065     1.980    0.000033
 3   -0.000101     1.980   -0.000051
 4   -0.000128     1.980   -0.000065
 5   -0.000418     1.980   -0.000211
 6   -0.000275     1.980   -0.000139
 7   -0.001345     1.980   -0.000679
 8   -0.000276     1.980   -0.000139
 9   -0.000244     1.980   -0.000123
```

Unstrained Data Should be Stored in Nonvolatile Media

```
STRAIN READINGS
CHANNEL                  MICROSTRAIN
 0                       -286
 1                         410
 2                        1165
 3                         417
 4                         291
 5                         776
 6                         257
 7                         142
 8                         351
 9                         117

--------------------------------------
```

Strain Readings from 10 Channels



Plot of Stress vs. Time Computated from Strain Gage Data taken on a Cantilever Beam

Use of a computer to control instrumentation, data manipulation, and storage gives us almost unlimited data output capability. With the wide varity of printers, displays and plotters available, the test data can be reduced and output by the computer in almost any conceivable format, often while the test is in process. With computational power and "smart" instrumentation, we can greatly increase the speed and accuracy of the measurement while eliminating the tedious manual-adjustment process. Now we have more time to concentrate on the test results.

"Courtesy of Radio Shack, Division of Tandy Corp."

"Courtesy of IBM"

"Courtesy of Apple Computer Inc."

"Courtesy of Hewlett Packard, Personal Computer Division"

Figure 35: A Desktop Computer with a μMEGA Can Be Used as an Instrumentation Controller

Appendices and Bibliography

Appendix A: Tables

WIRE RESISTANCE
Solid Copper Wire

AWG	Ohms/Foot (25°C)	Diameter (in.)
18	0.0065	0.040
20	0.0104	0.032
22	0.0165	0.0253
24	0.0262	0.0201
26	0.0416	0.0159
28	0.0662	0.0126
30	0.105	0.010
32	0.167	0.008

AVERAGE PROPERTIES OF SELECTED ENGINEERING MATERIALS
Exact values may vary widely

Material	Poisson's Ratio, ν	Modulus of Elasticity, E psi x 10^6	Elastic Strength (a) Tension (psi)
ABS (unfilled)	–	0.2-0.4	4500-7500
Aluminum (2024-T4)	0.32	10.6	48000
Aluminum (7075-T6)	0.32	10.4	72000
Red Brass, soft	0.33	15	15000
Iron-Gray Cast	–	13-14	–
Polycarbonate	0.285	0.3-0.38	8000-9500
Steel-1018	0.285	30	32000
Steel-4130/4340	0.28-0.29	30	45000
Steel-304 SS	0.25	28	35000
Steel-410 SS	0.27-0.29	29	40000
Titanium alloy	0.34	14	135000

(a) Elastic strength may be represented by proportional limit, yield point, or yield strength at 0.2 percent offset.

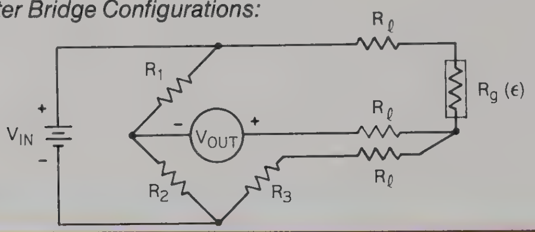
Appendix B: Bridge Circuits

STRAIN GAGE BRIDGE CIRCUITS AND EQUATIONS

Equations compute strain from unbalanced bridge voltages:
sign is correct for V_{IN} and V_{OUT} as shown
GF = Gage Factor: ν = Poisson's ratio:

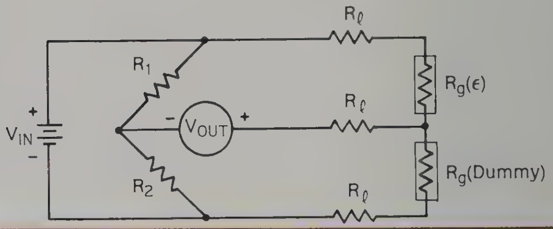
V_r = [(V_{OUT}/V_{IN})strained − (V_{OUT}/V_{IN})unstrained]:
ϵ = Strain: Multiply by 10^6 for micro-strain:
tensile is (+) and compressive is (−)

Quarter Bridge Configurations:



R_ℓ
R_1
$R_g\ (\epsilon)$
+
V_{IN}
-
R_ℓ
- V_{OUT} +
R_ℓ
R_2
R_3

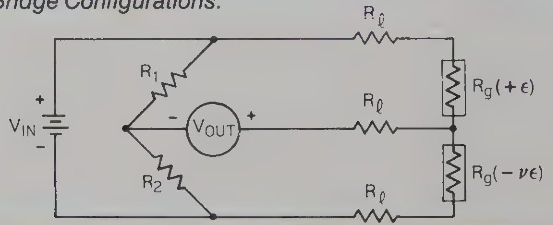
OR



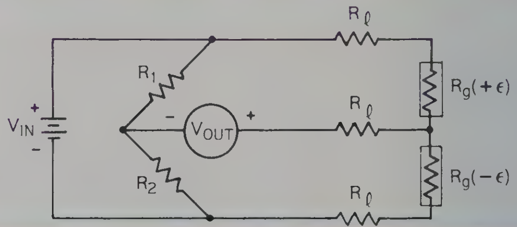
R_ℓ
R_1
$R_g(\epsilon)$
+
V_{IN}
-
R_ℓ
- V_{OUT} +
R_g(Dummy)
R_2
R_ℓ

$$\epsilon = \frac{-4V_r}{GF(1+2V_r)} \bullet \left(1 + \frac{R_\ell}{R_g}\right)$$

Half Bridge Configurations:



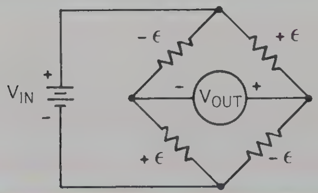
R_ℓ
R_1
$R_g(+\epsilon)$
+
V_{IN}
-
R_ℓ
- V_{OUT} +
R_2
$R_g(-\nu\epsilon)$
R_ℓ



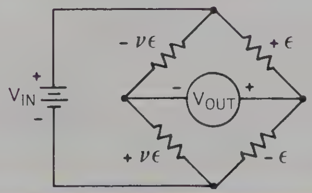
R_ℓ
R_1
$R_g(+\epsilon)$
+
V_{IN}
-
R_ℓ
- V_{OUT} +
R_2
$R_g(-\epsilon)$
R_ℓ

$$\epsilon = \frac{-4V_r}{GF[(1+\nu) - 2V_r(\nu-1)]} \bullet \left(1 + \frac{R_\ell}{R_g}\right) \qquad \epsilon = \frac{-2V_r}{GF} \bullet \left(1 + \frac{R_\ell}{R_g}\right)$$

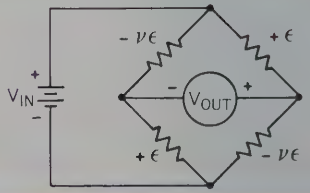
Full Bridge Configurations:



$-\epsilon$
$+\epsilon$
+
V_{IN}
-
- V_{OUT} +
$+\epsilon$
$-\epsilon$



$-\nu\epsilon$
$+\epsilon$
+
V_{IN}
-
- V_{OUT} +
$+\nu\epsilon$
$-\epsilon$



$-\nu\epsilon$
$+\epsilon$
+
V_{IN}
-
- V_{OUT} +
$+\epsilon$
$-\nu\epsilon$

$$\epsilon = \frac{-V_r}{GF} \qquad \epsilon = \frac{-2V_r}{GF(\nu+1)} \qquad \epsilon = \frac{-2V_r}{GF[(\nu+1) - V_r(\nu-1)]}$$

ppendix C: Equations

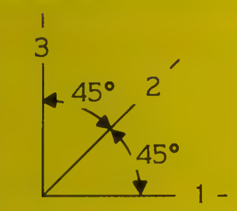
IAXIAL STRESS STATE EQUATIONS

$$\epsilon_x = \frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} \qquad \epsilon_z = -\nu\frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} \qquad \sigma_y = \frac{E}{1-\nu^2}(\epsilon_y + \nu\,\epsilon_x)$$

$$\epsilon_y = \frac{\sigma_y}{E} - \nu\frac{\sigma_x}{E} \qquad \sigma_x = \frac{E}{1-\nu^2}(\epsilon_x + \nu\,\epsilon_y) \qquad \sigma_z = 0$$

OSETTE EQUATIONS

ectangular Rosette:

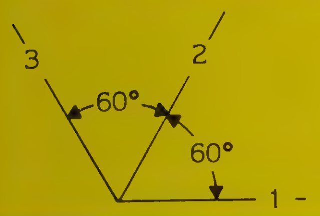


$$\epsilon_{p,q} = \frac{1}{2}\left[\epsilon_1 + \epsilon_3 \pm \sqrt{(\epsilon_1-\epsilon_3)^2 + (2\epsilon_2-\epsilon_1-\epsilon_3)^2}\right]$$

$$\sigma_{p,q} = \frac{E}{2}\left[\frac{\epsilon_1+\epsilon_3}{1-\nu} \pm \frac{1}{1+\nu}\sqrt{(\epsilon_1-\epsilon_3)^2 + (2\epsilon_2-\epsilon_1-\epsilon_3)^2}\right]$$

$$\theta_{p,q} = \frac{1}{2}\,\mathrm{TAN}^{-1}\frac{2\epsilon_2-\epsilon_1-\epsilon_3}{\epsilon_1-\epsilon_3}$$

elta Rosette:



$$\epsilon_{p,q} = \frac{1}{3}\left[\epsilon_1 + \epsilon_2 + \epsilon_3 \pm \sqrt{2[(\epsilon_1-\epsilon_2)^2 + (\epsilon_2-\epsilon_3)^2 + (\epsilon_3-\epsilon_1)^2]}\right]$$

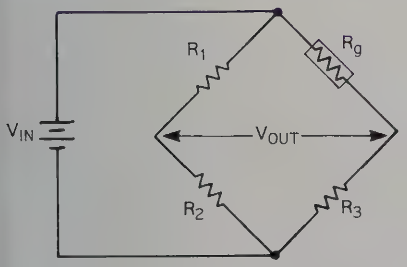
$$\sigma_{p,q} = \frac{E}{3}\left[\frac{\epsilon_1+\epsilon_2+\epsilon_3}{1-\nu} \pm \frac{1}{1+\nu}\sqrt{2[(\epsilon_1-\epsilon_2)^2 + (\epsilon_2-\epsilon_3)^2 + (\epsilon_3-\epsilon_1)^2]}\right]$$

$$\theta_{p,q} = \frac{1}{2}\,\mathrm{TAN}^{-1}\frac{\sqrt{3}(\epsilon_2-\epsilon_3)}{2\epsilon_1-\epsilon_2-\epsilon_3}$$

WHERE: $\epsilon_{p,q}$ = Principal strains; $\sigma_{p,q}$ = Principal stresses; and $\theta_{p,q}$ = the acute angle from the axis of gage 1 to the nearest principal axis. When positive, the direction is the same as that of the gage numbering and when negative, opposite.

NOTE: Corrections may be necessary for transverse sensitivity, refer to gage manufacturers literature.

ppendix D: Instrumentation Accuracy



¼ Bridge Circuit

Measurement error (in $\mu\epsilon$) due to the instrumentation is often difficult to determine from published specifications. However, accuracy can be computed using the following simplified error expressions. For the ¼ bridge, add equations 1-6 (N = 1). For the ½ bridge with two active arms, add equations 2-6 (N = 2). For the full bridge with four active arms, add equations 3-6 (N = 4).

The total error for a measurement must also include gage, lead wire, and, if applicable, bridge nonlinearity errors. These are discussed in the body of this application note. Additionally, other equipment imperfections which vary from instrument to instrument must occasionally be considered (e.g., offsets caused by leakage currents due to humidity or ionic contamination on p.c. boards and connectors).

1) R$_3$ change from unstrained to strained reading (due to temperature, load life, etc.)

$$\epsilon_{error} \approx -\frac{\Delta R_3/R_3}{GF}$$

Appendices and Bibliography (continued)

(2) $\frac{R_1}{R_2}$ change from unstrained to strained reading (due to temperature, load life, etc.)

$$\epsilon_{error} \approx \frac{\Delta \frac{R_1}{R_2} \frac{R_1}{R_2}}{GF \bullet N}$$

Digital voltmeters and A/D converters are specified in terms of a ± gain error (% of reading) and a ± offset error (number of counts, in volts). Since strain calculations require two measurements, a repeatable offset error, e.g., due to relay thermal EMF, etc., will cancel, but offset due to noise and drift will not. Assuming that noise and drift dominate, the offset on two readings will be the root sum of squares of the two offsets. This is incorporated into the formulas.

(3) DVM offset error on bridge measurement

$$\epsilon_{error} \lesssim \frac{-4}{V_{IN} \bullet GF \bullet N} \bullet \sqrt{(\text{Offset Error}_{strained})^2 + (\text{Offset Error}_{unstrained})^2}$$

Error terms 4-6 can usually be ignored when using high accuracy DVMs (e.g., 5½ digit). These error terms are essentially the product of small bridge imbalance voltages with small gain or offset terms. For equations 4-6, V_{OUT}, the bridge imbalance voltage, is a measured quantity which varies from channel to channel. To calculate worst case performance, the equations use resisto tolerances and measured strain eliminating the need for an exac knowledge of V_{OUT}.

(4) DVM gain error on bridge measurement

$$\epsilon_{error} \approx \frac{-4}{GF \bullet V_{IN} \bullet N} \bullet [(V_{OUT}) \bullet (\text{Gain Error})_{\text{strained reading}} - (V_{OUT}) \bullet (\text{Gain Error})_{\text{unstrained reading}}]$$

$$\lesssim -\epsilon_{measured} \bullet (\text{Gain Error})_{\text{strained reading}} - \frac{\sum \text{tolerances on } R_1/R_2, R_3, R_g}{GF \bullet N} \bullet \begin{pmatrix}\text{Gain Error change} \\ \text{strained-unstrained}\end{pmatrix}$$

The bridge excitation supply can be monitored with a DVM or preset using a DVM and allowed to drift. In the first case, supply related errors are due only to DVM gain and offset terms, assuming a quiet supply. In the second case, since power supply accuracy is usually specified in terms of a ± gain and a ± offset from the initial setting, identical equations can be used. Also for the second case, note that the strained reading gain error is the sum of the DVM an excitation supply gain errors, while the strained reading offset error is the root sum of squares of the DVM and excitation supply offset errors.

(5) Offset error on supply measurement (or on supply drift)

$$\epsilon_{error} \approx \frac{4}{GF \bullet V_{IN}^2 \bullet N} \bullet [(V_{OUT}) \bullet (\text{Offset Error})_{\text{strained reading}} - (V_{OUT}) \bullet (\text{Offset Error})_{\text{unstrained reading}}]$$

$$\lesssim \frac{\epsilon_{measured}}{V_{IN}} \bullet (\text{Offset Error})_{\text{strained reading}} + \frac{\sum \text{tolerances on } R_1,/R_2, R_3, R_g}{V_{IN} \bullet GF \bullet N} \bullet \sqrt{(\text{Offset Error}_{strained})^2 + (\text{Offset Error}_{unstrained})^2}$$

(6) Gain error on supply measurement (or on supply drift)

$$\epsilon_{error} \approx \frac{4}{GF \bullet V_{IN} \bullet N} \bullet [(V_{OUT}) \bullet (\text{Gain Error})_{\text{strained reading}} - (V_{OUT}) \bullet (\text{Gain Error})_{\text{unstrained reading}}]$$

$$\lesssim \epsilon_{measured} \bullet (\text{Gain Error})_{\text{strained reading}} + \frac{\sum \text{tolerances on } R_1/R_2, R_3, R_g}{GF \bullet N} \bullet \begin{pmatrix}\text{Gain error change} \\ \text{strained-unstrained}\end{pmatrix}$$

XAMPLE

Evaluate the error for a 24-hour train measurement with a ±5°C in- trumentation temperature varia- ion. This includes the DVM and the ridge completion resistors but not he gages. The hermetically sealed esistors have a maximum TCR of ±3.1 ppm/°C, and have a ±0.1% olerance. The DVM/Scanner com- ination, over this time and temper- ture span, has a 0.004% gain error nd a 4 μV offset error on the 0.1 olt range where the bridge output oltage, V_{OUT}, will be measured. The xcitation supply is to be set at 5 V sing the DVM. The DVM has a .002% gain error and a 100 μV off- et error on the 10 volt range. Over he given time and temperature pan, the supply has a 0.015% gain rror and a 150 μV offset error and vill not be remeasured. The mount- d gage resistance tolerance is ssumed to be ±0.5% or better. he strain to be measured is 3000 $\mu\epsilon$ nd the gage factor is assumed to be +2.

Notice that the temperature, as iven, can change by as much as ±10°C between the unstrained and trained measurements. This is the emperature change that must be sed to evaluate the resistor hanges due to TCR. The R_1/R_2 ratio as the tolerance and TCR of two esistors included in its specification o the ratio tolerance is ±0.2% and he ratio TCR is ±6.2 ppm/°C. **The ain error change on the bridge out- ut measurement, and on the excita- ion measurement, can be as much s twice the gain error specification.** he following table shows the total rror and the contribution of the in- ividual error equations 1-6.

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THE HEWLETT PACKARD COMPANY for permission to reproduce
their article **Application Note 290-1—Practical Strain Gage Measurements.**

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Equation	¼ Bridge	½ Bridge	Full Bridge
(1) R_3	15.5	–	–
(2) R_1/R_2	31.0	15.5	–
(3) V_{OUT} offset	2.3	1.1	0.6
(4) V_{OUT} gain	0.4	0.4	0.3
(5) V_{IN} offset	0.3	0.2	0.2
(6) V_{IN} gain	1.3	1.1	1.0
Sum	±50.8 $\mu\epsilon$	±18.3 $\mu\epsilon$	±2.1 $\mu\epsilon$

CONCLUSIONS

Based upon this example, several important conclusions can be drawn:

- Surprisingly large errors can result even when using state of the art bridge completion resistors and measuring equipment.
- Although typical measurements will have a smaller error, the numbers computed reflect the guaranteed instrumentation performance.
- Measuring the excitation supply for both the unstrained and strained readings not only results in smaller errors but allows the use of an inexpensive supply.
- Bridge completion resistor drift limits quarter and half bridge performance. Changes due to temperature, moisture absorption, and load life, require the use of ultra-stable hermetically sealed resistors.

STRAIN GAGE TECHNICAL DATA

THE STRAIN GAGE IS ONE OF THE MOST IMPORTANT TOOLS of the electrical measurement technique applied to the measurement of mechanical quantities. As their name indicates, they are used for the measurement of strain. As a technical term "strain" comprises of tensile and compressive strain, distinguished by a positive or negative sign. Thus, strain gages can be used to pick up expansion as well as contraction.

The strain of a body is always caused by an external influence or an internal effect. Strain might be caused by forces, pressures, moments, heat, structural changes of the material and the like. If certain conditions are fulfilled, the amount or the value of the influencing quantity can be derived from the measured strain value. In experimental stress analysis this feature is widely used. Experimental stress analysis uses the strain values measured on the surface of a specimen or structural part to state the stress in the material and also to predict its safety and endurance. Special transducers can be designed for the measurement of forces or other derived quantities, e.g., moments, pressures, accelerations, and displacements, vibrations and others. The transducer generally contains a pressure sensitive diaphragm with strain gages bonded to it.

Strain gage dimensions

The active grid length, in the case of foil gages, is the net grid length without the tabs and comprises the return loops of the wire gages.

The carrier dimensions are designed by OMEGA for the optimum function of the strain gage.

Strain gage resistance

The resistance of a strain gage is defined as the electrical resistance measured between the two metal ribbons or contact areas intended for the connection of measurement cables. The range comprises strain gages with a nominal resistance of 120, 350, 600, and 700 Ohms.

Gage factor (strain sensitivity)

The strain sensitivity k of a strain gage is the proportionality factor between the relative change of the resistance.

The strain sensitivity is a figure without dimension and is generally called gage factor.

The gage factor of each production lot is determined by sample measurements and is given on each package as the nominal value with its tolerance.

Reference temperature

The reference temperature is the ambient temperature for which the technical data of the strain gages are valid, unless temperature ranges are given.

The technical data quoted for strain gages are based on a reference temperature of 23°C.

Temperature characteristic

Temperature dependent changes of the specific strain gage grid resistance occur in the applied gage owing to the linear thermal expansion coefficients of the grid and specimen materials. These resistance changes appear to be mechanical strain in the specimen. The representation of the apparent strain as a function of temperature is called the temperature characteristic of the strain gage application.

In order to keep apparent strain through temperature changes as small as possible, each strain gage is matched during the production to a certain linear thermal expansion coefficient. The ranges offer strain gages with temperature characteristics matched to ferritic steel, aluminum, plastic, austenitic steel, titanium, molybdenum, or quartz.

Order Numbers for strain gages indicate the matched temperature characteristics.

This machine is denoted by the last figure of the strain gage type designation as follows:

1 for ferritic steel	with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]
3 for aluminum	with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]
5 for austenitic steel	with $\alpha = 16 \cdot 10^{-6}$/K [8.9 ppm/°F]
6 for quartz	with $\alpha = 0$
7 for titanium	with $\alpha = 9 \cdot 10^{-6}$/K [5 ppm/°F]
8 for plastics	with $\alpha = 65 \cdot 10^{-6}$/K [36.1 ppm/°F]
9 for molybdenum	with $\alpha = 5.4 \cdot 10^{-6}$/K [3 ppm/°F]

For example the temperature characteristic of strain gages with the type designation LY 11, XY 21, RY 31 and LG 11 are matched to steel with $\alpha = 11 \cdot 10^{-6}$/K since the last figure is 1.

Service temperature range

The service temperature range is the range of ambient temperature where the use of the strain gages is permitted without permanent changes of the measurement properties. Service temperature ranges are different whether static or dynamic values are to be sensed.

Maximum permitted rms bridge energizing voltage

The maximum values quoted are only permitted for appropriate application on materials with good heat conduction (e.g., steel of sufficient thickness) if room temperature is not exceeded. In other cases temperature rise in the measuring grid area may lead to measurement errors. Measurements on plastics and other materials with bad heat conduction require the reduction of the energizing voltage or the duty cycle (pulsed operation).

TECHNICAL DATA
Y SERIES FOIL STRAIN GAGES
Polyimid Carrier

Strain gage design		Foil strain gage with embedded measuring grid
Measuring grid		
Material		Constantan foil
Thickness	µ	3 or 5, depending on gage type
Carrier		
Material		Polyimid
Substrate thickness	µm	25 ±5
Cover thickness	µm	12 ±2
Connections		Nickel plated Cu ribbons about 30 mm
except for LY 41/43, LY 61/63, RY 31/33, RY 71/73, RY 81/83		integral terminals about 1.5 mm long and 1.6 . . . 2.2 mm wide
Nominal resistance	Ω	120, 350 or 700 depending on type
Resistance tolerance per package	%	±0.2**
except for KY types, per chain	%	±0.5
Gage factor		approx. 2
Nominal value of gage factor		given on package
Gage factor tolerance	%	±1
Reference temperature	°C [°F]	23 [73]
Service temperature range		
for static measurements	°C [°F]	−70 . . . +200 [−90 . . . +390]
for dynamic measurements	°C [°F]	−200 . . . +200 [−330 . . . +390]
Temperature characteristic		given in package
Temperature characteristic matched to thermal expansion coefficient		
α for ferritic steel	1/K [1/°F]	$11 \cdot 10^{-6}$ [6.1 ppm] (all gages)
α for aluminum	1/K [1/°F]	$23 \cdot 10^{-6}$ [12.7 ppm]
α for plastic	1/K [1/°F]	$65 \cdot 10^{-6}$ [36.1 ppm]
α for austenitic steel	1/K [1/°F]	$16 \cdot 10^{-6}$ [8.9 ppm] (on request)
α for titanium	1/K [1/°F]	$9 \cdot 10^{-6}$ [5 ppm] (on request)
α for molybdenum	1/K [1/°F]	$5.4 \cdot 10^{-6}$ [3 ppm] (on request)
α for quartz	1/K [1/°F]	0 (on request)
Tolerance of temperature characteristic	1/K [1/°F]	$\pm 1 \cdot 10^{-6}$ [±0.5 ppm]
Temperature range of matching	°C [°F]	+10 . . . +120 [+50 . . . 250]
Mechanical hysteresis* at reference temperature and at strain $\epsilon = \pm 1000 \mu m/m$ gage type 6/120 LY 11		
for 1st load cycle and adhesive Z 70	µm/m	1
for 3rd load cycle and adhesive Z 70	µm/m	0.5
for 1st load cycle and adhesive X 60	µm/m	2.5
for 3rd load cycle and adhesive X 60	µm/m	1
Maximum elongation* at reference temperature, adhesive Z 70 used at strain gage type 6/120 LY 11		
strain amount ϵ in positive sense	µm/m	50000 (△ 5%)
strain amount ϵ in negative sense	µm/m	50000 (△ 5%)
Fatigue properties* at reference temperature adhesive X 60 used at strain gage type 6/120 LY 61		
No. of load cycles achieved at oscillating strain $\epsilon_w = \pm 1000$ µm/m and zero point change		
$\Delta\epsilon_m \leq 300$ µm/m		>> 10^7 (test stopped after 10^7)
$\Delta\epsilon_m \leq 30$ µm/m		> 10^7 (test stopped after 10^7)
Smallest bending radius, longitudinal and lateral, at reference temperature		
for strain gages with ribbons	mm	0.3
for strain gages with integral terminals		
near the connections	mm	0.3
near the terminals	mm	2
Adhesives used		
cold curing adhesives		Z 70; X 60
hot curing adhesives		EP 310

*Data depend on various application parameters, therefore only given for representative examples.

**At 0.6 mm grid length, the nominal resistance may deviate by ±1%.

OMEGA®/HBM
Y SERIES FOIL STRAIN GAGES

Polyimid Carrier

a
HBM
b
c
HBM
a
b
c
HBM
HBM

General Purpose Strain Gages for Static or Dynamic Applications

- **Very flexible, mechanically strong**
- **Small bending radius—0.3 mm**
- **5% maximum elongation**
- **Broad temperature range**
- **Ribbon connectors or Integral terminals**
- **Clear alignment marks**
- **Affix with cold or hot curing adhesives**

Y Series strain gages are available in a broad selection to cover most strain measurement applications. Their rugged construction and flexibility make them suitable for static and dynamic measurement with a high degree of accuracy.

The measuring grid is formed by etching 3 µm or 5 µm Constantan foil which is then completely sealed in the carrier of polyimid film.

On account of this tough polyimid film the Y Series gages are very flexible, have good tensile strength, and are rugged. The tight bending radius allows the strain gages to be used on complex parts.

▶ Most Popular Models ◀

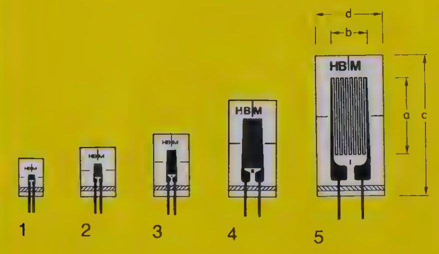
The most popular strain gage models in stock for fast delivery are highlighted by an arrow. Delivery of these models are normally *off-the-shelf*.

Other models or special temperature characteristic models will have longer delivery times.

When you place your order, consult with the Sales Department for exact delivery times.

1 MEASURING GRID

▶ HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY ◀

Type series / Diagrams to actual size	Order Model No.	Price per pkg. of 10	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
• Ribbon Leads Parallel to grid **LY 11** Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]	HBM 0.6/120 LY 11	**$51.50**	120	0.6	1.0	5.0	3.2	1.5	10	1
	HBM 1.5/120 LY 11	**45.00**	120	1.5	1.2	6.5	4.7	2.5	10	2
▶	HBM 3/120 LY 11	**40.00**	120	3	1.4	8.3	4.7	4.5	10	3
	HBM 6/120 LY 11	**43.50**	120	6	2.8	12.8	6.3	9	10	4
	HBM 10/120 LY 11	**55.50**	120	10	4.9	18.5	9.5	15	10	5
▶	HBM 3/350 LY 11	**46.00**	350	3	1.5	8.3	4.7	9	10	≈3
	HBM 6/350 LY 11	**46.00**	350	6	2.9	12.8	6.3	15	10	≈4
	HBM 10/350 LY 11	**76.50**	350	10	5	18.3	9.5	26	10	≈5
	HBM 0.6/120 LY 13	**51.50**	120	0.6	1.0	5.0	3.2	1.5	10	1
	HBM 1.5/120 LY 13	**45.00**	120	1.5	1.2	6.5	4.7	2.5	10	2
▶	HBM 3/120 LY 13	**38.00**	120	3	1.4	8.3	4.7	4.5	10	3
	HBM 6/120 LY 13	**44.00**	120	6	2.8	12.8	6.3	9	10	4
	HBM 10/120 LY 13	**55.50**	120	10	4.9	18.5	9.5	15	10	5
	HBM 3/350 LY 13	**46.00**	350	3	1.5	8.3	4.7	9	10	≈3
	HBM 6/350 LY 13	**46.00**	350	6	2.9	12.8	6.3	15	10	≈4
LY 13 Temperature characteristic matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]	HBM 10/350 LY 13	**76.50**	350	10	5	18.3	9.5	26	10	≈5

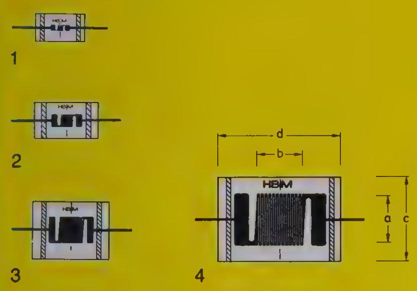
OMEGA® /HBM
Y SERIES FOIL STRAIN GAGES

Polyimid Carrier

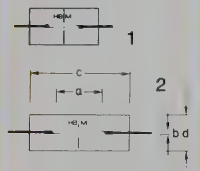
1 MEASURING GRID

➧ HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY ◆

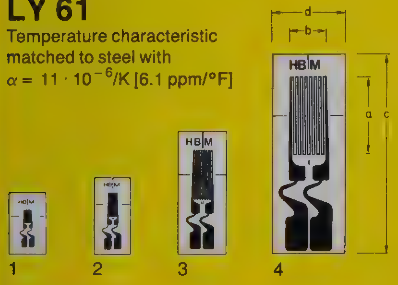
- **Ribbon Leads Perpendicular to grid**



- **Small Area Gages Axial Leads**



- **Solder Pad Terminals Integral strain relief**



Type Series	Order Model No.	Price per pkg. of 10	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
LY 21 Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]	HBM 0.6/120 LY 21	$57.50	120	0.6	0.7	3.5	6.4	1.5	10	1
	HBM 1.5/120 LY 21	44.00	120	1.5	1.6	4.7	8.3	3.5	10	2
	▶ HBM 3/120 LY 21	52.50	120	3	3.3	7.5	10	7	10	3
	HBM 6/120 LY 21	65.00	120	6	6.5	11	16	10	10	4
LY 51 Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]	HBM 3/120 LY 51	55.50	120	3	0.3	9	4.7	2.5	10	1
	HBM 6/120 LY 51	46.00	120	6	0.4	13	4.7	3.5	10	2
LY 58 Temperature characteristic matched to plastic with $\alpha = 65 \cdot 10^{-6}$/K [36.1 ppm/°F]	HBM 3/120 LY 58	55.50	120	3	0.3	9	4.7	2.5	10	1
	HBM 6/120 LY 58	55.50	120	6	0.4	13	4.7	3.5	10	2
LY 61 Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]	HBM 1.5/120 LY 61	56.50	120	1.5	1.2	8	4.7	2.5	10	1
	▶ HBM 3/120 LY 61	52.50	120	3	1.4	10	4.7	4.5	10	2
	HBM 6/120 LY 61	52.50	120	6	2.8	16	6.3	9	10	3
	HBM 10/120 LY 61	70.00	120	10	4.9	26	9.5	15	10	4
	HBM 3/350 LY 61	61.00	350	3	1.5	10	4.7	7.5	10	≈2
	HBM 6/350 LY 61	54.50	350	6	2.9	16	6.3	15	10	≈3
	HBM 10/350 LY 61	71.00	350	10	4.8	26	9.5	26	10	≈4
LY 63 Temperature characteristic matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]	HBM 1.5/120 LY 63	56.50	120	1.5	1.2	8	4.7	2.5	10	1
	▶ HBM 3/120 LY 63	52.50	120	3	1.4	10	4.7	4.5	10	2
	HBM 6/120 LY 63	52.50	120	6	2.8	16	6.3	9	10	3
	HBM 10/120 LY 63	70.00	120	10	4.9	26	9.5	15	10	4
	HBM 6/350 LY 63	54.50	350	6	2.9	16	6.3	15	10	≈3

Diagrams to actual size

Y SERIES FOIL STRAIN GAGES

Polyimid Carrier

1 Measuring Grid

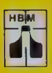
HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY

Type Series — Diagrams to actual size

- **Solder Pad Terminals**
- **50, 100, 150 mm Models for inhomogeneous material**

LY 41

Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]



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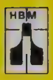

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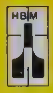

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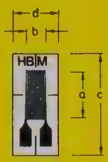

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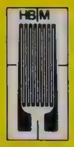
Order Model No.	Price per pkg. of 10	nominal resistance [Ohm]	dimensions [mm]				max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
			grid		carrier				
			a	b	c	d			
HBM 0.6/120 LY 41	**$46.00**	120	0.6	1.2	7.9	5.9	1.5	10	1
HBM 1.5/120 LY 41	**38.00**	120	1.5	1.3	9.2	5.9	2.5	10	2
HBM 3/120 LY 41	**39.00**	120	3	1.2	10.9	5.9	4.5	10	3
HBM 6/120 LY 41	**35.50**	120	6	2.9	13.9	5.9	9	10	4
HBM 10/120 LY 41	**51.50**	120	10	5.3	18	8	15	10	5
HBM 20/120 LY 41	**79.50**	120	20	5	30.2	8.2	18	10	6
HBM 50/120 LY 41	**143.50**	120	50	5	62.8	8.2	25	10	7
HBM 100/120 LY 41	**143.50**	120	100	5	113.8	8.2	30	10	8
HBM 150/120 LY 41	**259.50**	120	150	5	165.6	8.2	35	10	9
HBM 1.5/350 LY 41	**35.50**	350	1.5	2.8	9.2	5.9	4	10	≈2
HBM 3/350 LY 41	**39.00**	350	3	2.7	10.9	5.9	7.5	10	≈3
HBM 6/350 LY 41	**38.00**	350	6	3.4	13.9	5.9	15	10	≈4
HBM 10/350 LY 41	**49.50**	350	10	5.3	18	8	21	10	≈5
HBM 3/700 LY 41	**51.50**	700	3	2.8	10.9	5.9	10	10	≈3
HBM 6/700 LY 41	**43.00**	700	6	4.1	13.9	5.9	21	10	≈4
HBM 10/700 LY 41	**63.00**	700	10	5.3	18	8	28	10	≈5
HBM 20/700 LY 41	**79.50**	700	20	5	30.2	8.2	32	10	≈6
HBM 50/700 LY 41	**113.00**	700	50	5	60.8	8.2	40	10	≈7
HBM 100/700 LY 41	**163.00**	700	100	5	111.5	8.2	50	10	≈8
HBM 150/700 LY 41	**270.00**	700	150	5	161.4	8.2	50	10	≈9



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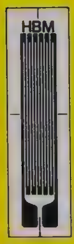

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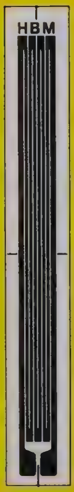

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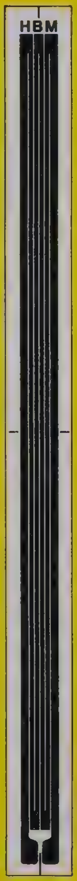

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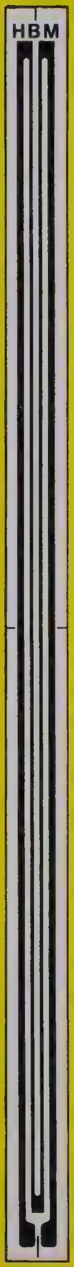

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LY 43

Temperature characteristic matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]

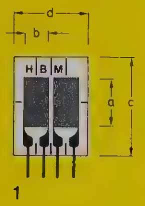
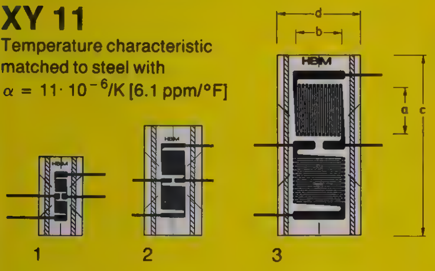
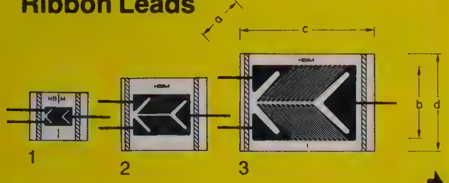
Order Model No.	Price per pkg. of 10	nominal resistance [Ohm]	dimensions [mm]				max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
			grid		carrier				
			a	b	c	d			
HBM 0.6/120 LY 43	**$46.00**	120	0.6	1.2	7.9	5.9	1.5	10	1
HBM 1.5/120 LY 43	**38.00**	120	1.5	1.3	9.2	5.9	2.5	10	2
HBM 3/120 LY 43	**39.00**	120	3	1.2	10.9	5.9	4.5	10	3
HBM 6/120 LY 43	**35.50**	120	6	2.9	13.9	5.9	9	10	4
HBM 10/120 LY 43	**51.50**	120	10	5.3	18	8	15	10	5
HBM 20/120 LY 43	**79.50**	120	20	5	30.2	8.2	18	10	6
HBM 50/120 LY 43	**143.50**	120	50	5	62.8	8.2	25	10	7
HBM 100/120 LY 43	**143.50**	120	100	5	113.8	8.2	30	10	8
HBM 150/120 LY 43	**259.50**	120	150	5	165.6	8.2	35	10	9
HBM 1.5/350 LY 43	**35.50**	350	1.5	2.8	9.2	5.9	4	10	≈2
HBM 3/350 LY 43	**39.00**	350	3	2.7	10.9	5.9	7.5	10	≈3
HBM 6/350 LY 43	**38.00**	350	6	3.4	13.9	5.9	15	10	≈4
HBM 10/350 LY 43	**49.50**	350	10	5.3	18	8	21	10	≈5
HBM 3/700 LY 43	**51.50**	700	3	2.8	10.9	5.9	10	10	≈3
HBM 6/700 LY 43	**43.00**	700	6	4.1	13.9	5.9	21	10	≈4
HBM 10/700 LY 43	**63.00**	700	10	5.3	18	8	28	10	≈5
HBM 20/700 LY 43	**79.50**	700	20	5	30.2	8.2	32	10	≈6
HBM 50/700 LY 43	**113.00**	700	50	5	60.8	8.2	40	10	≈7
HBM 100/700 LY 43	**163.00**	700	100	5	111.5	8.2	50	10	≈8
HBM 150/700 LY 43	**270.00**	700	150	5	161.4	8.2	50	10	≈9

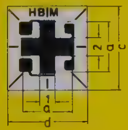
Y SERIES FOIL STRAIN GAGES

Polyimid Carrier

2 Measuring Grids

▶HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY◀

Type Series	Diagrams to actual size	Order Model No.	Price per pkg. of 5	nominal resistance [Ohm]	dimensions [mm]				max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
					grid		carrier				
					a	b	c	d			
• **Double Strain Gage Ribbon Leads**											
DY 11 Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]		HBM 6/350 DY 11	**46.00**	350	6	3.2	12.5	9.4	15	5	1
• **90° Axis Double Strain Gage Ribbon Leads**											
XY 11 Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]		HBM 1.5/120 XY 11	**52.50**	120	1.5	1.6	10.3	5.7	3	5	1
		▶ HBM 3/120 XY 11	**45.00**	120	3	3.4	14.3	7.5	6	5	2
		HBM 6/120 XY 11	**67.00**	120	6	6.8	23.5	10.8	12	5	3
		HBM 3/350 XY 11	**57.50**	350	3	3.3	14.4	7.3	10	5	2
		HBM 6/350 XY 11	**76.50**	350	6	6.5	23.3	10.5	20	5	3
XY 13 Temperature characteristic matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]		HBM 1.5/120 XY 13	**52.50**	120	1.5	1.6	10.3	5.7	3	5	1
		HBM 3/120 XY 13	**45.00**	120	3	3.4	14.3	7.5	6	5	2
		HBM 6/120 XY 13	**67.00**	120	6	6.8	23.5	10.8	12	5	3
• **45° Axis for Torque Measurement Ribbon Leads**											
XY 21 Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]		HBM 1.5/120 XY 21	**51.50**	120	1.5	2.5	7.6	6.3	3.5	5	1
		▶ HBM 3/120 XY 21	**46.00**	120	3	5.3	11.2	9.5	6.5	5	2
		HBM 6/120 XY 21	**46.00**	120	6	10	17.5	12.7	14	5	3
		HBM 6/350 XY 21	**63.00**	350	6	10	17.5	12.7	21	5	3

Type Series	Diagrams to actual size	Order Model No.	Price per pkg.	nominal resistance [Ohm]	dimensions [mm]					max. permissible bridge excitation voltage [V rms]	contents of package [pieces]	Fig.
					a	b_1	b_2	c	d			
• **90° Axis with Stacked Grids Ribbon Leads**												
XY 91 Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]	 1	▶ HBM 3/120 XY 91	101.50	120	3	1.5	1.4	7.9	6.2	4.5	5	–
		HBM 6/120 XY 91	101.50	120	6	1.9	2.2	10.0	9.6	9	5	–
		HBM 10/120 XY 91	**105.50**	120	10	3.3	3.8	15.2	14.0	15	5	1
XY 93 Temperature characteristic matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]		HBM 3/120 XY 93	**101.50**	120	3	1.5	1.4	7.9	6.2	4.5	5	–
		HBM 6/120 XY 93	**101.50**	120	6	1.9	2.2	10.0	9.6	9	5	–
		HBM 10/120 XY 93	**105.50**	120	10	3.3	3.8	15.2	14.0	15	5	1

3 MEASURING GRIDS

▶HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY◀

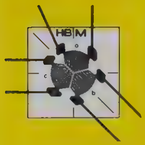
Type Series — Diagrams to actual size

• Large Area Rosette 0°/45°/90° Ribbon Leads

RY 11

0°/45°/90° rosette
Temperature characteristic
matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]

Order Model No.	Price per pkg. of 5	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
▶ HBM 6/120 RY 11	$ 82.50	120	6	—	12	12	6	5	1
HBM 10/120 RY 11	91.00	120	10	—	16	16	8	5	2
HBM 15/120 RY 11	114.00	120	15	—	23	23	12	5	—



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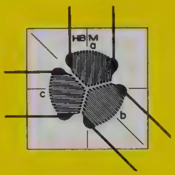

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RY 13

0°/45°/90° rosette
Temperature characteristic
matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]

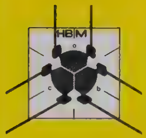
Order Model No.	Price per pkg. of 5	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
HBM 6/120 RY 13	82.50	120	6	—	12	12	6	5	1
HBM 10/120 RY 13	91.00	120	10	—	16	16	8	5	2
HBM 15/120 RY 13	114.00	120	15	—	23	23	12	5	—

• 0°/60°/120° Ribbon Leads

RY 41

0°/60°/120° rosette
Temperature characteristic
matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]

Order Model No.	Price per pkg. of 5	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
▶ HBM 6/120 RY 41	79.50	120	6	—	12	12	6	5	1
HBM 10/120 RY 41	95.00	120	10	—	16	16	8	5	2
HBM 15/120 RY 41	104.50	120	15	—	23	23	12	5	—



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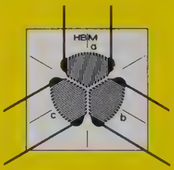


2

RY 43

0°/60°/120° rosette
Temperature characteristic
matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]

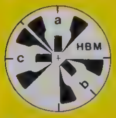
Order Model No.	Price per pkg. of 5	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
HBM 6/120 RY 43	79.50	120	6	—	12	12	6	5	1
HBM 10/120 RY 43	95.00	120	10	—	16	16	8	5	2
HBM 15/120 RY 43	104.50	120	15	—	23	23	12	5	—

• Small Area Rosette 0°/45°/90° Solder Pad Terminals

RY 31

0°/45°/90° rosette
Temperature characteristic
matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]

Order Model No.	Price per pkg. of 5	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
▶ HBM 6/120 RY 31	100.50	120	6	1.1	14	—	3.5	5	1
HBM 10/120 RY 31	79.50	120	10	2.3	18	—	6	5	2
HBM 15/120 RY 31	94.00	120	15	2.4	23	—	8.5	5	—



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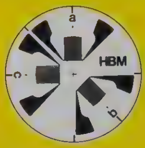

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RY 33

0°/45°/90° rosette
Temperature characteristic
matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]

Order Model No.	Price per pkg. of 5	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
HBM 6/120 RY 33	100.50	120	6	1.1	14	—	3.5	5	1
HBM 10/120 RY 33	79.50	120	10	2.3	18	—	6	5	2
HBM 15/120 RY 33	94.00	120	15	2.4	23	—	8.5	5	—

Y SERIES FOIL STRAIN GAGES

Polyimid Carrier

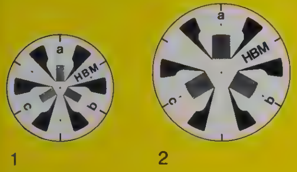
3 MEASURING GRIDS

▶ HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY ◀

Type Series — Diagrams to actual size

• Small Area Rosette 0°/60°/120° Solder Pad Terminals

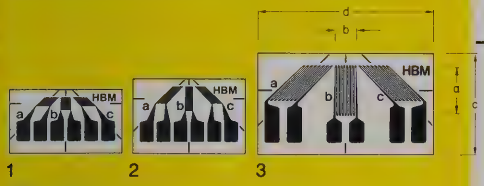
RY 71
0°/60°/120° rosette
Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]



RY 73
0°/60°/120° rosette
Temperature characteristic matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]

• Edge Cluster 0°/45°/90° Solder Pad Terminals

RY 81
0°/45°/90° edge rosette
Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]

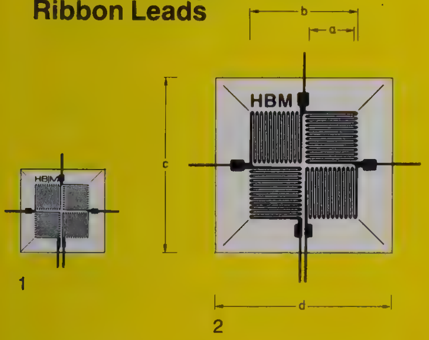


RY 83
0°/45°/90° edge rosette
Temperature characteristic matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]

Type Series	Order Model No.	Price per pkg. of 5	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
RY 71	▶ HBM 6/120 RY 71	$ 76.50	120	6	1.1	14	—	3.5	5	1 ◀
RY 71	HBM 10/120 RY 71	87.00	120	10	2.3	18	—	6	5	2
RY 71	HBM 15/120 RY 71	132.00	120	15	2.4	23	—	8.5	5	—
RY 73	HBM 6/120 RY 73	76.50	120	6	1.1	14	—	3.5	5	1
RY 73	HBM 10/120 RY 73	87.00	120	10	2.3	18	—	6	5	2
RY 73	HBM 15/120 RY 73	132.00	120	15	2.4	23	—	8.5	5	3
RY 81	HBM 1.5/120 RY 81	63.00	120	1.5	1.2	8.2	14.6	2.5	5	1
RY 81	▶ HBM 3/120 RY 81	71.00	120	3	0.9	9.6	14.6	3.5	5	2 ◀
RY 81	HBM 6/120 RY 81	81.50	120	6	2.6	13.2	22.9	9	5	3
RY 83	HBM 1.5/120 RY 83	63.00	120	1.5	1.2	8.2	14.6	2.5	5	1
RY 83	HBM 3/120 RY 83	71.00	120	3	0.9	9.6	14.6	3.5	5	2
RY 83	▶ HBM 6/120 RY 83	81.50	120	6	2.6	13.2	22.9	9	5	3 ◀

4 MEASURING GRIDS

• 90° Full Bridge Cluster Ribbon Leads



VY 11
90° full bridge rosette
Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]

Type Series	Order Model No.	Price per pkg. of 5	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
VY 11	▶ HBM 3/120 VY 11	111.00	120	3	7	13.5	13.5	10	5	1 ◀
VY 11	HBM 6/120 VY 11	163.00	120	6	14	23	23	20	5	2

Y SERIES FOIL STRAIN GAGES

Polyimid Carrier

STRAIN GAGE CHAINS

HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY

• 10 Measuring Grids

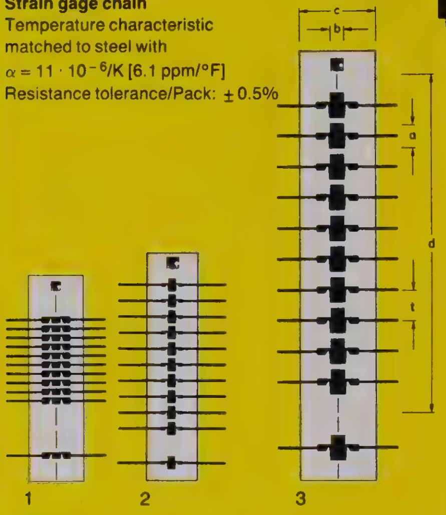
Parallel to Axis
plus 1 compensation gage

KY 11

Strain gage chain
Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]
Resistance tolerance/Pack: ±0.5%

Order Model No.	Price per pkg of 1	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
HBM 1/120 KY 11	$75.50	120	0.6	1	7.2	14.5	1.5	1	1
HBM 2/120 KY 11	55.50	120	1.5	1.3	6.7	24.5	3.5	1	2
HBM 4/120 KY 11	57.50	120	3	2.1	9.5	44.5	5	1	3

Diagrams to actual size



The single strain gage at the end of the carrier foil should be cut away before the application of the strain gage chain. It can be used for temperature compensation or to form a half bridge configuration.

KY 13

Strain gage chain
Temperature characteristic matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]
Resistance tolerance/Pack: ±0.5%

Order Model No.	Price per pkg of 1	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
HBM 1/120 KY 13	75.50	120	0.6	1	7.2	14.5	1.5	1	1
HBM 2/120 KY 13	55.50	120	1.5	1.3	6.7	24.5	3.5	1	2
HBM 4/120 KY 13	57.50	120	3	2.1	9.5	44.5	5	1	3

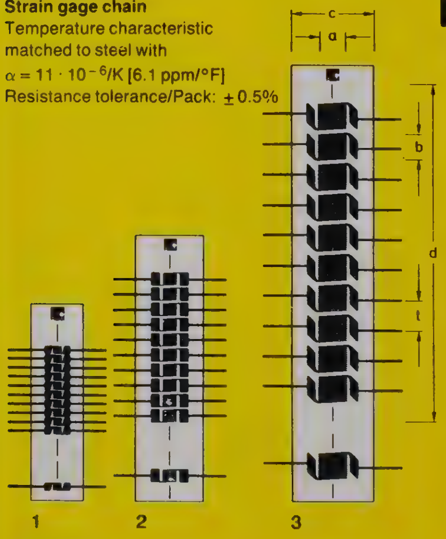
• 10 Measuring Grids

Perpendicular to Axis
plus 1 compensation gage

KY 21

Strain gage chain
Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]
Resistance tolerance/Pack: ±0.5%

Order Model No.	Price per pkg of 1	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
HBM 1/120 KY 21	70.00	120	0.8	0.8	6.9	15	1.5	1	1
HBM 2/120 KY 21	65.00	120	1.7	1.7	9.5	24.5	3.5	1	2
HBM 4/120 KY 21	61.00	120	3.4	3.5	10.8	45	7	1	3



The single strain gage at the end of the carrier foil should be cut away before the application of the strain gage chain. It can be used for temperature compensation or to form a half bridge configuration.

KY 23

Strain gage chain
Temperature characteristic matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]
Resistance tolerance/Pack: ±0.5%

Order Model No.	Price per pkg of 1	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
HBM 1/120 KY 23	70.00	120	0.8	0.8	6.9	15	1.5	1	1
HBM 2/120 KY 23	65.00	120	1.7	1.7	9.5	24.5	3.5	1	2
HBM 4/120 KY 23	61.00	120	3.4	3.5	10.8	45	7	1	3

STRAIN GAGE CHAINS

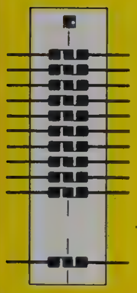
HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY

Type Series	Diagrams to actual size	Order Model No.	Price per pkg. of 1	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
KY 41		HBM 2/120 KY 41	**$61.00**	120	1.2	1.3	9.2	24.5	3.5	1	1
		HBM 4/120 KY 41	**79.50**	120	3	3	11.5	44.5	6	1	2
KY 43		HBM 2/120 KY 43	**61.00**	120	1.2	1.3	9.2	24.5	3.5	1	1
		HBM 4/120 KY 43	**79.50**	120	3	3	11.5	44.5	6	1	2
KY 31		HBM 4/120 KY 31	**79.50**	120	1.3	4.1	8.3	25.0	3	1	1

- **10 Measuring Grids**
  5 Parallel to Axis
  5 Perpendicular to Axis
  plus 1 compensation gage

KY 41

Strain gage chain
Temperature characteristic
matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]
Resistance tolerance/Pack: ±0.5%



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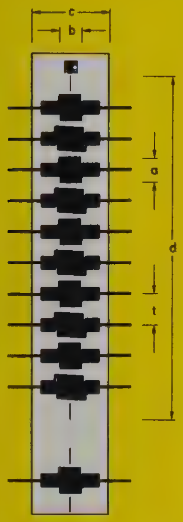

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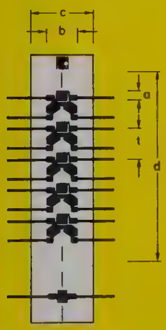
The single strain gage at the end of the carrier foil should be cut away before the application of the strain gage chain. It can be used for temperature compensation or to form a half bridge configuration.

KY 43

Strain gage chain
Temperature characteristic
matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]
Resistance tolerance/Pack: ±0.5%

- **Cluster Chain**
  5 Clusters of three strain gages
  0°/60°/120°



1

The single strain gage at the end of the carrier foil should be cut away before the application of the strain gage chain. It can be used for temperature compensation or to form a half bridge configuration.

KY 31

Strain gage cluster
Temperature characteristic
matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]
Resistance tolerance/Pack: ±0.5%

G SERIES FOIL STRAIN GAGES

Phenolic Carrier

- **Rugged Glass Reinforced Phenolic Carrier**
- **Ribbon Leads Secured by Carrier**
- **3 mm Bending Radius**
- **Service Temperature to 260°C**
- **Alignment Marks**
- **Work with Cold or Hot Curing Adhesives**

The G Series foil strain gages have a rugged glass reinforced phenolic carrier and pull-out resistant ribbon lead wires. This construction technique allows them to be used in severe environments or general purpose static or dynamic applications where a long life transducer is required.

Most Popular Models

The most popular strain gage models in stock for fast delivery are highlighted by an arrow. Delivery of these models in modest quantities is normally *off-the-shelf*. Delivery of other models or special temperature characteristic models will be significantly longer. When you place your order, consult with the Sales Department for exact delivery times.

Technical Data of the G Series Foil Strain Gages

Strain gage design		Foil strain gage with embedded measuring grid
Measuring grid		
Material		Constantan foil
Thickness	µm	3 or 5, depending on gage type
Carrier		
Material		Phenolic resin with glass fiber reinforcement
Substrate thickness	µm	35 ±10
Cover thickness	µm	25 ± 8
Connections		Nickel plated Cu ribbons about 30 mm long
Nominal resistance	Ω	120, or 350 depending on type
Resistance tolerance per package	%	±0.2**
Gage factor		Approx. 2
Nominal value of gage factor		Given on package
Gage factor tolerance	%	±1
Reference temperature	°C [°F]	23 [73]
Service temperature range		
for static measurements	°C [°F]	−70 . . . +200 [−90 . . . +390]
for dynamic measurements	°C [°F]	−200 . . . +260 [−330 . . . +500]
Temperature characteristic		Given on package
Temperature characteristic matched to thermal expansion coefficient		
α for ferritic steel	1/K [1/°F]	$11 \cdot 10^{-6}$ [6.1 ppm] (all gages)
α for aluminum	1/K [1/°F]	$23 \cdot 10^{-6}$ [12.7 ppm] (see table)
α for plastic	1/K [1/°F]	$65 \cdot 10^{-6}$ [36.1 ppm] (on request)
α for austenitic steel	1/K [1/°F]	$16 \cdot 10^{-6}$ [8.9 ppm] (on request)
α for titanium	1/K [1/°F]	$9 \cdot 10^{-6}$ [5 ppm] (on request)
α for molybdenum	1/K [1/°F]	$5.4 \cdot 10^{-6}$ [3 ppm] (on request)
α for quartz	1/K [1/°F]	0 (on request)
Tolerance of temperature characteristic	1/K [1/°F]	$\pm 1 \cdot 10^{-6}$ [±0.5 ppm]
Temperature range of matching	°C [°F]	+10 . . . +120 [+50 . . . +250]
Mechanical hysteresis*		
at reference temperature and at strain $\epsilon = \pm 1000$ µm/m		
at strain gage type 6/120 LG 11		
for 1st load cycle and adhesive EP 310	µm/m	0.5
for 3rd load cycle and adhesive EP 310	µm/m	0.5
for 1st load cycle and adhesive X 60	µm/m	3
for 3rd load cycle and adhesive X 60	µm/m	1.5
Maximum elongation*		
at reference temperature, adhesive Z 70 used		
at strain gage type 6/120 LG 11		
strain amount ϵ in positive sense	µm/m	20,000 (=2%)
strain amount ϵ in negative sense	µm/m	50,000 (=5%)
Fatigue properties*		
at reference temperature, adhesive Z 70 and oscillating strain $\epsilon_W = \pm 1{,}000$ µm/m used at strain gage type 6/120 LG 11		
No. of load cycles and		
zero point change $\Delta\epsilon_m \leq 300$ µm/m		$7 \cdot 10^5$
$\Delta\epsilon_m \leq 30$ µm/m		$1 \cdot 10^4$
Smallest bending radius, at reference temperature	mm	3
Adhesives used		
cold curing adhesives		Z 70; X 60
hot curing adhesives		EP 310

*Data depend on various application parameters, therefore only given for representative examples.

**At 0.6 mm grid length the nominal resistance may deviate by ±1%.

G SERIES FOIL STRAIN GAGES

Phenolic Carrier

1 MEASURING GRID

HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY

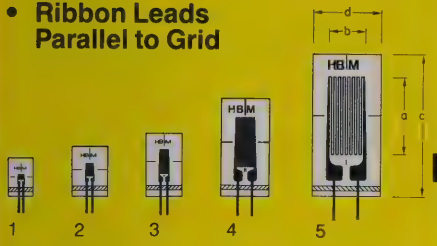
Type Series — Diagrams to actual size

LG 11

Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]

Order Model No.	Price per pkg.	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
HBM 0.6/120 LG 11	$52.50	120	0.6	1.0	5	3.2	1.5	10	1
HBM 1.5/120 LG 11	52.50	120	1.5	1.2	6.5	4.7	4	10	2
HBM 3/120 LG 11	44.00	120	3	1.4	8.3	4.7	6	10	3
HBM 6/120 LG 11	46.00	120	6	2.8	12.8	6.3	11	10	4
HBM 10/120 LG 11	55.50	120	10	4.9	18.5	9.5	18	10	5
HBM 3/350 LG 11	48.00	350	3	1.5	8.3	4.7	9	10	≈3
HBM 6/350 LG 11	40.00	350	6	2.9	12.8	6.3	15	10	≈4
HBM 10/350 LG 11	65.00	350	10	5.0	18.5	9.5	26	10	≈5

- **Ribbon Leads Parallel to Grid**

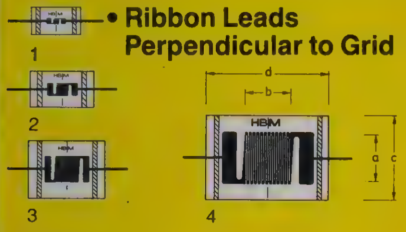


LG 13

Temperature characteristic matched to aluminum with $\alpha = 23 \cdot 10^{-6}$/K [12.7 ppm/°F]

Order Model No.	Price per pkg.	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
HBM 0.6/120 LG 13	52.50	120	0.6	1.0	5	3.2	1.5	10	1
HBM 1.5/120 LG 13	52.50	120	1.5	1.2	6.5	4.7	4	10	2
HBM 3/120 LG 13	44.00	120	3	1.4	8.3	4.7	6	10	3
HBM 6/120 LG 13	46.00	120	6	2.8	12.8	6.3	11	10	4
HBM 10/120 LG 13	55.50	120	10	4.9	18.5	9.5	18	10	5
HBM 3/350 LG 13	48.00	350	3	1.5	8.3	4.7	9	10	≈3
HBM 6/350 LG 13	40.00	350	6	2.9	12.8	6.3	15	10	≈4
HBM 10/350 LG 13	65.00	350	10	5.0	18.5	9.5	26	10	≈5

- **Ribbon Leads Perpendicular to Grid**



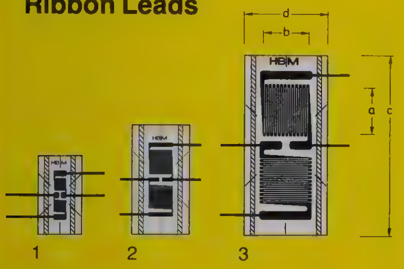
LG 21

Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]

Order Model No.	Price per pkg.	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
HBM 0.6/120 LG 21	76.50	120	0.6	0.7	3.5	6.4	1.5	10	1
HBM 1.5/120 LG 21	61.00	120	1.5	1.6	4.7	8.3	4	10	2
HBM 3/120 LG 21	51.50	120	3	3.3	7.5	10	8.5	10	3
HBM 6/120 LG 21	79.50	120	6	6.5	11	16	17	10	4

2 MEASURING GRIDS

- **90° Axis Double Strain Gage Ribbon Leads**

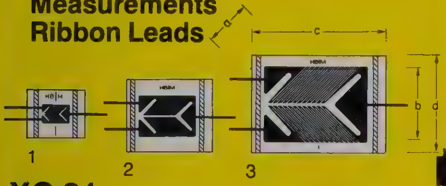


XG 11

Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]

Order Model No.	Price per pkg.	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
HBM 1.5/120 XG 11	55.50	120	1.5	1.6	10.3	5.7	5	5	1
HBM 3/120 XG 11	55.50	120	3	3.4	14.3	7.5	8	5	2
HBM 6/120 XG 11	67.00	120	6	6.8	23.5	10.8	16	5	3
HBM 3/350 XG 11	55.50	350	3	3.3	14.4	7.3	10	5	≈2
HBM 6/350 XG 11	63.00	350	3	6.5	23.3	10.5	20	5	≈3

- **45° Axis for Torque Measurements Ribbon Leads**



XG 21

Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]

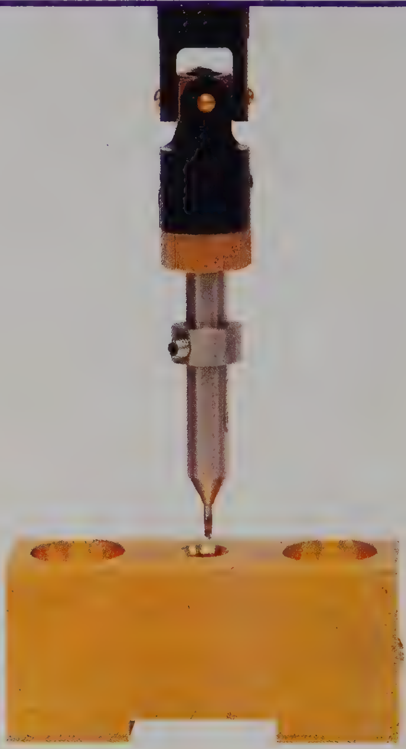
Order Model No.	Price per pkg.	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
HBM 1.5/120 XG 21	42.00	120	1.5	2.5	7.6	6.3	3.5	5	1
HBM 3/120 XG 21	46.00	120	3	5.3	11.2	9.5	6.5	5	2
HBM 6/120 XG 21	52.50	120	6	10	17.5	12.7	14	5	3
HBM 6/350 XG 21	49.50	350	6	10	17.5	12.7	21	5	≈3

Residual Stress

Strain gage rosettes according to the ring core method or the hole drilling method are used for the determination of residual stress states in the surface of a test specimen. Usually the ring core or hole drilling rosettes are applied on flat surfaces with the cold curing rapid adhesive X 60.

The polyimid carrier is supported by a printed circuit made from Teflon in the ring core rosette XY 51 and RY 51 and in the hole drilling rosette RY 61.

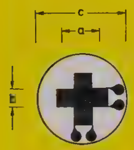
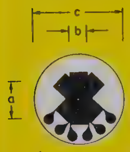
The technical data of the ring core and hole drilling rosettes are identical to Y series foil strain gages (see page E-34), except for the matching of the temperature characteristic of the XY 51, RY 51 and RY 61 rosettes. Only cold curing adhesives are recommended for the application.



Drilling Kit for RY-61 Strain Gages

- **Simple Measuring Procedure**
- **Small Hole Diameter—1.5 mm**
- **Small Hole Depth—1.5 mm**
- **Easy-to-use Drill and Holder**

The drilling rosette serves to detect internal stresses by the hole drilling method. This method can be used to determine the internal stress conditions in the surfaces of objects. The internal stresses present in the object are released by drilling a hole in it. They cause strains in the vicinity of the hole, which can be measured at the surface of the object with strain gages. To position the hole required for this method exactly in the center of the rosette, OMEGA supplies a simple centering and drilling aid, RY-61-Drill.

Type Series Diagrams to actual size	Order Model No.	Price per pkg. of 5	nominal resistance [Ohm]	dimensions [mm]				max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
				grid		carrier				
				a	b	c	d			
• **Ring Core Rosette** 0°/90°  1 **XY 51** Strain gages with integral terminals Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F] Temperature range of the matching of the temperature characteristic: +10 . . . +60°C [+50° . . . +140°F]	HBM 5/350 XY 51	**$142.50**	350	5	2.5	12	—	5	5	1
• **Ring Core Rosette** 0°/45°/90°  1 **RY 51** **0°/45°/90° ring core rosette** Strain gages with integral terminals Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F] Temperature range of the matching of the temperature characteristic: +10 . . . +60°C [+50° . . . +140°F]	HBM 5/350 RY 51	**193.50**	350	5	2.5	12	—	5	5	1

SPECIAL STRAIN GAGES

Measuring procedure

To release the internal stresses, the material must be drilled exactly in the center of the drilling rosette mounted on it. The problems connected with this lie in the drilling operation. Center punching is not possible, as this would modify the internal stresses in the area around the rosette. In addition, the drill should exert the smallest possible pressure on the walls of the hole.

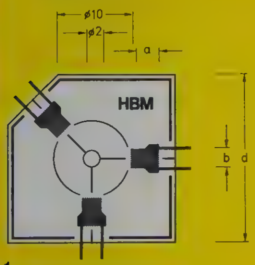
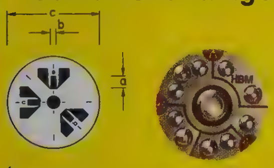
As an aid for making the hole, OMEGA offers a simple set of accessories, comprising a magnetic holder, a centering pin, a shaft drill, and a universal joint. By using the centering bushing in the rosette, one can dispense with time-consuming operations such as aligning the drill guide with a microscope.

RY-61-Drill

$159

as shown

HIGHLIGHTED MODELS STOCKED FOR FAST DELIVERY

Type Series / Diagrams to actual size	Order Model No.	Price per pkg. of 5	nominal resistance [Ohm]	dimensions [mm] grid a	grid b	carrier c	carrier d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
• Hole Drilling Rosette 0°/45°/90°  1 **RY 21** **0°/45°/90° hole drilling rosette** Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]	HBM 3/120 RY 21	**$ 74.50**	120	3	1.9	—	22	5	5	1
• Hole Drilling Rosette-Bushing Center for Drilling Kit 0°/45°/90°  1 **RY 61** **0°/45°/90° hole drilling rosette** Strain gages with integral connections Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F] Temperature range of the matching of the temperature characteristic: +10. . . +60°C [+50°. . . +140°F] OMEGA offers centering and drilling aid described on page E-29 for the execution of drilling.	HBM 1.5/120 RY 61	**114.00**	120	1.5	0.8	12	—	2.5	5	1

HIGH TEMPERATURE—TO 850°C

The Series LF 30 high temperature free grid strain gages are designed to measure strains at high temperatures, e.g., on internal combustion engines, steam turbines, reactors, etc. The wire measuring grid of the LF 30 consists of a platinum-tungsten alloy and is attached to a self adhesive glass fiber reinforced Teflon backing strip which serves as a mounting aid and is discarded during the mounting operation.

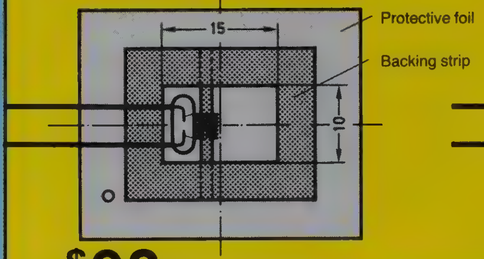
Mounting

The LF 30 high temperature free grid strain gages can be mounted with ceramic cement CR 760. A thin coat of the ceramic cement CR 760 applied before mounting the measuring grid acts at the same time as insulation between the object to be measured and the measuring grid. The weld-on cable terminals permit electrical connection of the measuring points. They consist of nickel tubes embedded in aluminum oxide, and a weld-on holding strip.

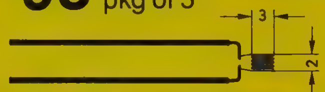
To Order

Model

HBM 3/120 LF 30



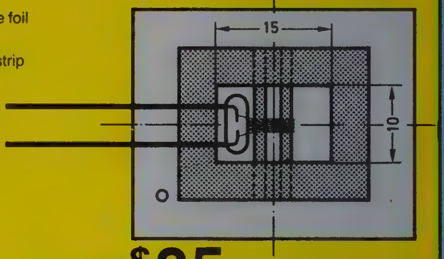
$98 pkg of 5



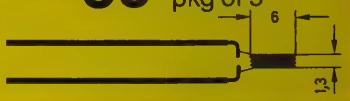
Illustrations are actual size

Model

HBM 6/120 LF 30



$85 pkg of 5



Wiring terminals SS 650

Shown larger than actual size

Weld-on terminals SS 650 (optional)

Nickel tubes embedded in aluminum oxide, 2-pole, with weld-on holding strip.
Contents of pack: 10 two-pole terminals and 10 holding strips.

See page E-56 for details

Technical Data

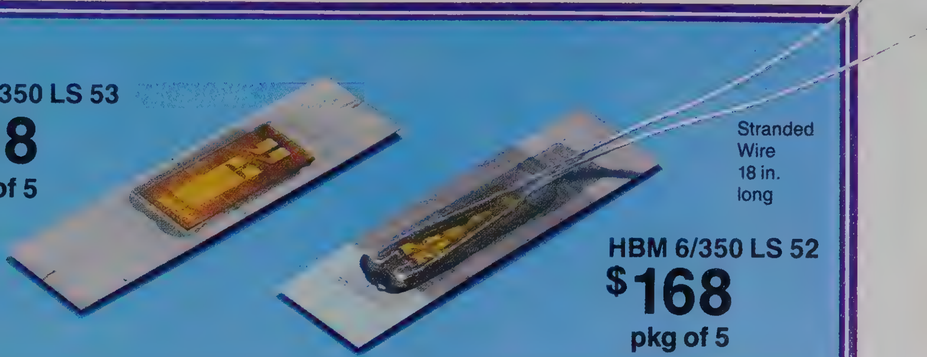
Type		3/120 LF 30 and 6/120 LF 30
Strain gage construction		High temperature free grid strain gage
Measuring grid material		Pt-W-alloy 1200
Carrier material		Detachable backing strip of self adhesive glass fiber reinforced Teflon
Connection strips		
Dimensions	mm	0.5 × 0.05
Material		X 7 CrNiAl 17 7 (1.4568)
Nominal resistance	Ω	120
Resistance tolerance per pack	%	±0.7
Gage factor		Approx. 4.5
Nominal value of gage factor		Indicated on the pack
Temperature coefficient of the gage factor	1/K	−310 · 10^{-6} ±5%
Maximum permissible bridge energizing voltage (rms value)	V	1.5 (at 3/120 LF 30) and 2 (at 6/120 LF 30)
Reference temperature	°C	+23
Service temperature range with ceramic cement CR 760 for		
static measurements	°C	−200… +760
dynamic measurements	°C	−230… +850
Temperature response of resistance		Non-self-compensating (compensation strain gage or measured value correction required)
Smallest bending radius at reference temperature	mm	5
Maximum static extensibility with CR mounting	%	0.5
Mounting agent		Ceramic cement CR 760
Contents per pack	pieces	5

SPECIAL STRAIN GAGES

WELD-ON STRAIN GAGE

The weld-on strain gages LS 52 and LS 53 are used for strain measurements and monitoring duties on large components, when strain gages cannot be applied by the adhesive method. Examples of these are the detection of strains on the stands of presses and punching machines, and strain measurements during shrinking-on procedures at high temperatures. The upper limit of the service temperature is +190°C for the LS 53 and +150°C for the LS 52.

The strain gages LS 52 and LS 53 consist of a constantan measuring grid foil which, with its polyimide encapsulation, is mounted on a metal carrier by a special adhesive process. In the LS 52, the foil strain gage is protected by a transparent silicon rubber cover against mechanical damage and moisture during handling. The 40 mm × 10 mm carrier is secured to the object to be measured by spot welding.



HBM6/350 LS 53
$138
pkg of 5

Stranded
Wire
18 in.
long

HBM 6/350 LS 52
$168
pkg of 5

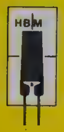
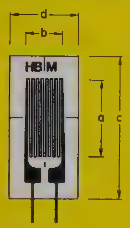
Technical Data

Type		LS 52 and LS 53
Strain gage construction	mm	Foil strain gage (quarter bridge) with polyimide carrier and constantan measuring grid, applied hot to carrier plate
Length of measuring grid	mm	6
Carrier plate		
l × w	mm	40 × 10
Thickness	mm	0.1
Material		X 8 Cr 17 (1.4016)
Nominal resistance	Ω	350
Resistance tolerance per pack	%	±1
Gage factor		Approx. 2
Nominal value of the gage factor		Stated on the pack
Maximum permissible bridge excitation voltage	V	15
Reference temperature	°C	+23
Service temperature range		
for LS 52	°C	−200 … +150
for LS 53	°C	−230 … +190
Temperature characteristic matched to thermal expansion coefficient α for ferritic steel	1/K	$11 \cdot 10^{-6}$
Temperature range for matching the temperature characteristic	°C	+10 … +120
Minimum radius of curvature at the reference temperature lengthwise and crosswise	mm	75
Maximum extensibility at reference temperature	µm/m	±3000 (= ±3%)
Restoring force related to strain	$\frac{N}{1000\ \mu m/m}$	< 250

HIGH STRESS— 10% ELONGATION

Strain gages of the LD 20 Series are used for extremely large positive or negative strains. Their maximum elongation is ± 10%.

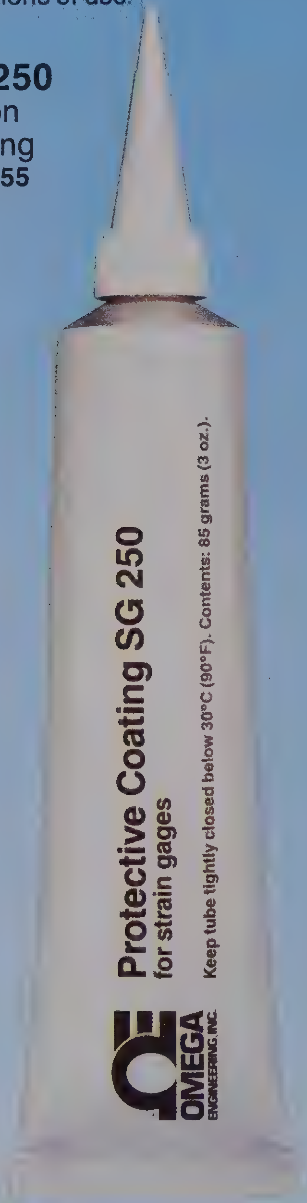
The technical data of strain gages for high strains are identical to Y series foil strain gages (see page E-36), except for the higher extensibility.

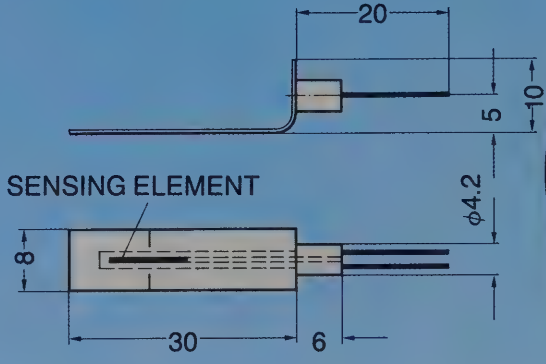
Type Series	Diagrams to actual size	Model No.	Price per pkg of 10	nominal resistance [Ohm]	dimensions [mm] grid a	b	carrier c	d	max. permitted bridge energizing voltage [V rms]	contents of package [pieces]	Fig.
LD 20 Temperature characteristic matched to steel with $\alpha = 11 \cdot 10^{-6}$/K [6.1 ppm/°F]	 1  2	HBM 6/120 LD 20	$60	120	6	2.8	12.8	6.3	9	10	1
		HBM 10/120 LD 20	70	120	10	4.9	18.5	9.5	15	10	2

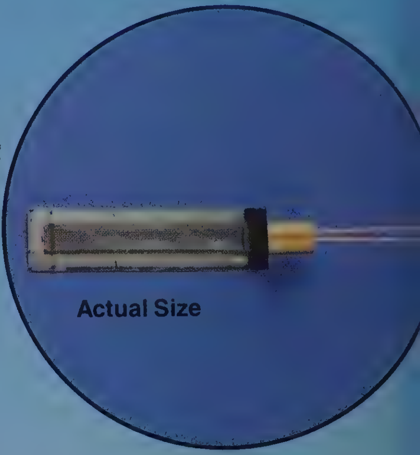
ENCAPSULATED STRAIN GAGES

Encapsulated strain gages are especially suitable for use in rough ambient conditions which necessitate a special protection of the strain gage. There are appropriate encapsulated strain gages available for various conditions of use.

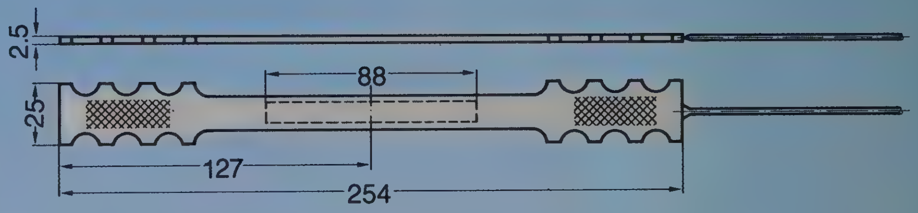
SG-250
Silicon
Coating
pg. E-55


Protective Coating SG 250
for strain gages
Keep tube tightly closed below 30°C (90°F). Contents: 85 grams (3 oz.).
OMEGA
ENGINEERING, INC.


20
10
5
SENSING ELEMENT
ϕ4.2
8
30
6


Actual Size

LS 11 Dimensions in Millimeters

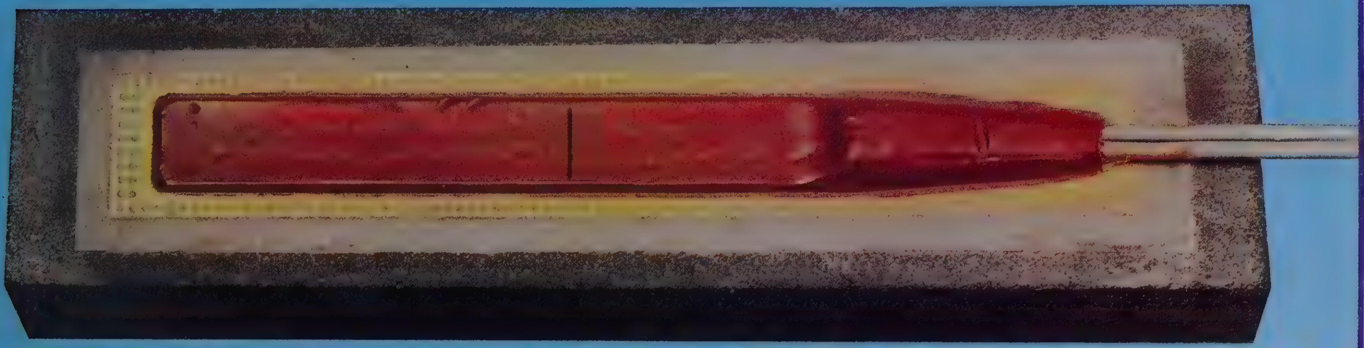

2.5
25
88
127
254

DA 3 Dimensions in Millimeters

DA 3 ⅓ actual size

Survey					
Type	Price	Application	Gages connected as	Temp. characteristic matched to	Nominal resistance
LS 11	$288.50	primarily for measurements on metallic objects e.g.; ships, heavy machinery, oil drilling platforms, scaffolding, etc.	quarter bridge	mild steel	120 ohm
DA 3	158.00	mainly for strain measurements on asphalt or concrete subjects; e.g. for determining pressures applied to aircraft runways, motorways, etc.	quarter bridge	concrete	350 ohm

SPECIAL STRAIN GAGES



Technical Data of the Encapsulated Strain Gages

Type		LS 11	DA 3
Strain gage design		foil strain gage, hermetic encapsulation	wire strain gage
Measuring grid material		Constantan foil	Constantan wire
Measuring grid length	mm	10	88
Carrier			
material		X 12 CrNi 18 8 • AISI 303	polycarbonate
thickness	mm	0.1	approx. 1.2
Cover material		X 7 CrNiAl 17 7 17-7-PH (Armco) 0.05 mm sheet metal	polycarbonate
Nominal resistance	Ω	120	350
Resistance tolerance per package	%	±1	
Gage factor		approx. 2	approx. 2
Nominal value of gage factor		quoted on each package	given on gage
Max. permitted bridge energizing voltage (rms)	V	6	6
Reference temperature	°C [°F]	+23 [+73]	+23 [+73]
Service temperature range			
applied with X 60	°C [°F]	−200 … +60 [−330 … +140]	−50 … +70 [−60 … +160]
spot welded	°C [°F]	−200 … +80 [−330 … +175] (+160°C with suitable cables) [+320°F]	
Temperature characteristic matched to temperature expansion coefficient α for ferritic steel	1/K [1/°F]	$11 \cdot 10^{-6}$ [6.1 ppm/°F]	
Temperature range of the matching of temperature characteristic	°C [°F]	+10 … +120 [+50 … +250]	*
Smallest bending radius at reference temperature, lengthwise and across	mm	75	—
Max. elongation at reference temperature	%	±0.3	±2
at 1,000 strain cycles	%		±0.1
at 10,000 strain cycles	%		±0.05
Reaction force related to strain	$\frac{N}{1000\ \mu m/m}$	< 300	approx. 180
Weight with cable, approx.	g		60
Connection cable, 5 m long			three screened cores twisted
Useable adhesives			
cold curing adhesive		X 60	X 60
spot welding		spot welding equipment	
Contents of package	pieces	5**	1

** If measurements are not at constant temperatures, a compensation gage embedded in the same material as the specimen shall be used.*

*** Each package is complete with two pieces of sheet metal for welding tests with heat shrinking tubes for sealing of the connections.*

STRAIN GAGE ACCESSORIES

OMEGA
ENGINEERING, INC.
An OMEGA Group Company
Kit X 60
X 60 Cold Curing Rapid Adhesive Component A
OMEGA

STRAIN GAGE ADHESIVES

X60 Kit Contents:
100 g ea. powder and liquid
9 mixing cups
2 measuring spoons
cellophane strips
mixing sticks

$63

EP310 Kit Contents:
70 cm³ component A
30 cm³ component B
5 mixing bottles
funnel
Teflon sheets
cellophane tape
rubber protective pad

$25

Shown smaller than actual size

Z 70
Cold Curing
Rapid
Adhesive
OMEGA
CR 760
Ceramic Putty
OMEGA

In Stock for Fast Delivery!

Potential Uses and Temperature Limits

Strain gage adhesive	Price	Temperature limits in °C [°F] lower, with stat./dyn. load	Temperature limits in °C [°F] upper, with static load	Temperature limits in °C [°F] upper, with dynamic load	foil gages series Y	foil gages series G	residual stress gages XY, RY	gages for high strains LD	high temperature gages LF	encapsulated gages LS	encapsulated gages DB, DA
X 60 Kit* Cold curing paste	$25.00	−200 [−330]	+60 [+140]	+80 [+175]	✔	✓	✔	✔		✔	✔
Z 70 Cold curing rapid adhesive	9.50	−200 [−330]	+100 [+210]	+120 [+250]	✔	✓	✔	✔			
EP 310 Kit Hot curing adhesive	63.00	−270 [−455]	+310 [+590]	+310 [+590]	✔	✔		✔			
CR 760 Ceramic putty	75.50	−200/−230 [−330/−380]	+760 [+1400]	+850 [+1560]					✔		

✔ **Ideal application**
✓ **Limited application (check specs)**

*Refill Package Available—Specify X60 Refill (400 g each component)—**$25.50**

STRAIN GAGE ACCESSORIES

OMEGA ENGINEERING, INC.
An OMEGA Group Company
Kit EP 310
EP 310 Hot Curing Adhesive Component A
OMEGA
EP 310 Hot Curing Adhesive Component B
OMEGA

STRAIN GAGE ADHESIVES

It is the duty of strain gage adhesives to firmly connect the strain gages to the surface of the specimen and to transfer deformation by strains onto the strain gage without loss.

The main criteria for the selection of the strain gage adhesives are the carrier material of the strain gage to be applied and the temperature range for actual measurements. Cementing with plastic materials is a commonly used fixing method. Furthermore, there are spot welding and ceramic bonding agents which are used with special strain gages.

Strain gages are embedded in plastic resin or in concrete without special bonding agents.
Strain gage bonding agents are specially developed to meet the particular requirements in view of the various strain gage carrier materials. Therefore, it is strongly recommended to use only the strain gage adhesives listed in table below.

With respect to the application technique, the OMEGA range of accessories distinguishes cold curing adhesives, hot curing adhesives, ceramic putties, and spot welding connections.

Cold Curing Adhesives

Cold curing adhesives are easily processed with little effort since they cure at normal ambient temperatures. If their reaction times are short they are also called "rapid adhesives." Their preferred application is in experimental stress analysis.

Hot Curing Adhesives

Hot curing adhesives can be used if the measurement object can be heated up to the required curing temperature. This is usually feasible in the production of transducers, but also in cases where machine parts are gaged prior to mounting or are disassembled for gaging. Hot curing adhesives meet higher quality requirements and are usable in a larger temperature range than cold curing adhesives.

Ceramic Putty

The ceramic putty is only for use with free grid strain gages (special strain gages). They are preferably used in the high temperature range.

Technical Data

Strain gage adhesive	Contents	One package sufficient for approx.	No. of Compo-nents	Pot life @20°C	Optimum glueline thickness μm	Clamping pressure in N/mm^2	Curing temp. in °C [°F]	Curing time	Storage time	Temperature limits °C [°F]		
										lower	upper	
										at stat./ dyn. loading	at stat. loading[1])	at dyn. loading[2])
X 60 Cold curing paste	Comp. A (powder) Comp. B (liquid) each 100 g	100 strain gages	2	5 min	65 ± 15	Press with thumb	0 [32] ⋮ 20 [70] ⋮ 35 [95]	approx. 60 min ⋮ approx. 10 min ⋮ approx. 2 min	1 year at room temp.	−200 [−330]	+60 [+140]	+80 [+175]
Refill package	400 g per component	400 strain gages										
Z 70 Cold curing rapid adhesive	bottle of 10 cm^3	250 strain gages	1	—	8 ± 2	Press with thumb	5 [40] 20 [70] 30 [85]	approx. 10 min approx. 2 min approx 0.5 min	5 months, stored cool	−200 [−330]	+100 [+210]	+120 [+250]
EP 310 Hot curing adhesive	70 cm^3 comp. A 30 cm^3 comp. B	300 strain gages	2	1 month 6 mos. (at +2°C)	10 ± 5	0.1…0.5	in steps 95 to 205 [205…400]	5 h…0.5 h	1 year at room temp.	−270 [−455]	+310 [+590]	+310 [+590]
CR 760 Ceramic putty	bottle of 25 g	50 strain gages	1	—	35 ± 15	—	180 [355]	1 h	1 year at room temp	−200/ −230 [−330/ −380]	+760 [+1400]	+850 [+1560]

PROTECTIVE COVERINGS FOR STRAIN GAGES

Protective Coating SG 250
for strain gages
OMEGA
ENGINEERING, INC.
Keep tube tightly closed below 30°C (90°F). Contents: 85 grams (3 oz.).
PU 100
Polyurethane
Varnish
OMEGA
ENGINEERING INC

Shown approximately ⅔ actual size

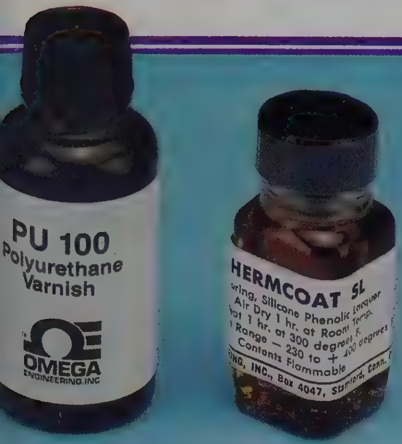
Protective Coverings for Strain Gages

Strain gages need protection against outer influences according to the ambient conditions: e.g. against humidity or mechanical damage.

In Stock for Immediate Delivery!

Survey: Possible Application and Technical Data

Strain gage cover	Price	Protects against	Temperature range of stability in air in °C [°F]	Contents of package	Package sufficient for about	Application method	Hardening conditions	Shelf life at 21°C	Composition
AK 22 Tough putty	$16.00	mechanical influences, weather, water (no vapor), pressurized water to 400 bar	−50… +170 [−58… +338]	1 kg	30 strain gages	knead on by hand	—	unlimited	tough kneadable putty, highly adhesive
ABM 75 Aluminum foil with putty	17.00	mechanical influences (Al foil must not be damaged), weather, water	−196… + 75 [−321… +167]	11 pieces 205 × 100 mm	200 strain gages	press on by hand	—	unlimited	aluminum laminate 0.05 mm thick with a 3 mm layer of putty
SG 250 Transparent silicon rubber	22.00	mechanical influences, weather, water at room temperature, oil	−70… +260 [−94… +500]	tube of approx. 85 g	20 strain gages	paste on from tube	air drying at room temperature	6 months	transparent single component silicon rubber, solvent-free
PU 100 Polyurethane varnish	23.00	mechanical influences, weather, oil, solvents	−32… +100 [−25… +212]	4 bottles 30 ml each	250 strain gages	brush on with small brush	room temperature up to… +100°C [+212°F]	1 year	single component polyurethane varnish containing solvents
Thermcoat SL Transparent silicon resin (2 oz.)	9.00	weather oil solvents	−155… +235 [−250… +450]	2 bottles 1 oz. ea.	90 strain gages	brush on with small brush	in temperature steps up to 200°C [up to 382°F]	9 months	transparent silicon resin, solvent-free


PU 100
Polyurethane
Varnish
OMEGA
ENGINEERING, INC
HERMCOAT SL
Silicone Phenolic Lacquer
Air Dry 1 hr. at Room Temp.
1 hr. at 300 degrees F.
Range – 230 to + 400 degrees F.
Contents Flammable
ING, INC., Box 4047, Stamford, Conn.

TERMINAL PADS AND BRIDGE RESISTORS

Strain Gage Connectors

When mounting strain gages with ribbon or wire connection, one should use connectors for soldering between the gage and the connection cables. This greatly facilitates a proper soldered connection and gives strain relief of the connections from tension through the cables. The connectors are mounted like the gage itself on the specimen. OMEGA offers strain gage connectors in many versions and sizes.

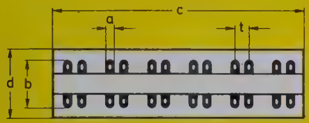
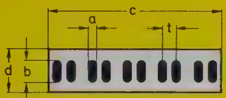
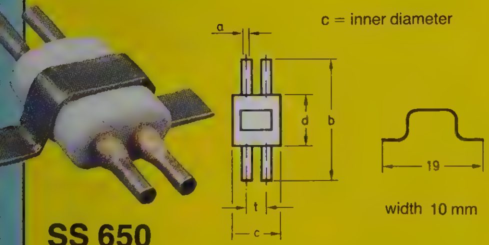
Complementary Half Bridges

Complementary half bridges are connected in the Wheatstone bridge circuit together with the strain gages of the measurement point. In accordance with the nominal strain gage resistances, OMEGA offers complementary half bridges with different resistance values.

Complementary Half Bridge

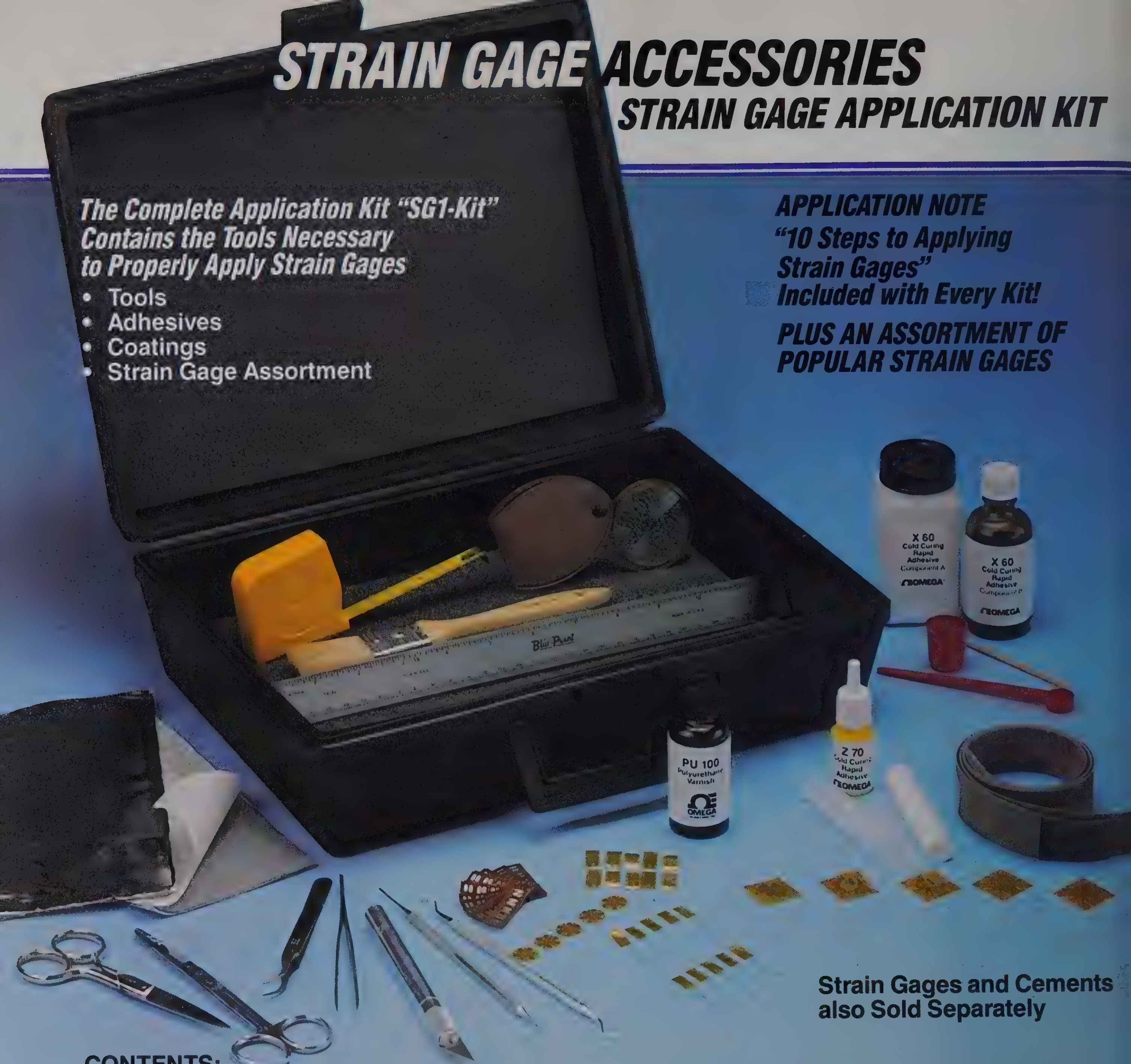
2 × 120 Ohm	Order No. HBM 2/120 HB
2 × 350 Ohm	Order No. HBM 2/350 HB
2 × 600 Ohm	Order No. HBM 2/600 HB

In Stock for Immediate Delivery!

Type	Figures See Table for Dimensions	Type	Order No.	Dimensions [mm]				Connector	Contents of Package
				Connector		Substrate			
				a	b	c	d	t	
LS 2 Bronze solder eyelets on Teflon substrate Suitable for dynamic stresses Fixing method on specimen: cementing Useable up to 180°C, short term 260°C [350°F, short term 500°F]		LS 2	214.02—2022	2.5	14	72	20	4	36 pairs
LS 7/5/4 Copper laminate on Teflon substrate Fixing method on specimen: cementing Useable up to 180°C, short term 260°C [350°F, short term 500°F]		LS 7 LS 5 LS 4	214.02—2027 214.02—2025 214.02—2024	1 1.5 2.5	3 4.5 6.5	20 35 50	6 10 13	2 2.5 4	125 pairs 125 pairs 125 pairs
SS 650 Nickel tubes embedded in Aluminum oxide: complete with weldable fasteners Useable up to 650°C, short term 750°C [1200°F, short term 1380°F]	 a c = inner diameter d b t c 19 width 10 mm	55650	214.02—2031	1	19	7.5	8	3	10 pieces

STRAIN GAGE ACCESSORIES

STRAIN GAGE APPLICATION KIT


Blue Point
X 60
Cold Curing
Rapid
Adhesive
Component A
OMEGA
X 60
Cold Curing
Rapid
Adhesive
Component B
OMEGA
PU 100
Polyurethane
Varnish
OMEGA
Z 70
Cold Curing
Rapid
Adhesive
OMEGA

The Complete Application Kit "SG1-Kit" Contains the Tools Necessary to Properly Apply Strain Gages

- Tools
- Adhesives
- Coatings
- Strain Gage Assortment

APPLICATION NOTE "10 Steps to Applying Strain Gages" Included with Every Kit!

PLUS AN ASSORTMENT OF POPULAR STRAIN GAGES

Strain Gages and Cements also Sold Separately

CONTENTS:

STRAIN GAGES

HBM-6/120-LY11 (pkg of 10)
HBM-6/120-RY11 (pkg of 5)
HBM-6/120-RY71 (pkg of 5)
HBM-3/120-LY41 (pkg of 10)
HBM-LS5 (125 pair)

COATINGS

ABM75 Aluminum Foil with Putty (Two 8¼″ × 4″ sheets)
PU100 Polyurethane Varnish (1 oz.)

ADHESIVES

X60 Adhesive (100 g Binder and Filler)
Z70 Adhesive (10 cm³)
Z70-ZN Quick-cure Additive (25 cm³)

APPLICATION NOTE

10 Steps to Applying Strain Gages

TOOLS

Flat Brush
Fold-Out Magnifier 6x Magn.
12″ Ruler
10′ Flexible Ruler
Glass Fiber Eraser
Scissors, Dented
Scissors, Pointed
Dental Probe with Bent Point
Dental Spatula for Cement
Stripper for Removing Insulation
Knife with Six Blades
10 ft. Roll Multicolored Ribbon Cable
Roll Mylar Tape
Rolls of 180, 240, 400 Grade
Emery Cloth
Straight Tweezers
Curved Tweezers

COMPLETE APPLICATION AND TOOL KIT

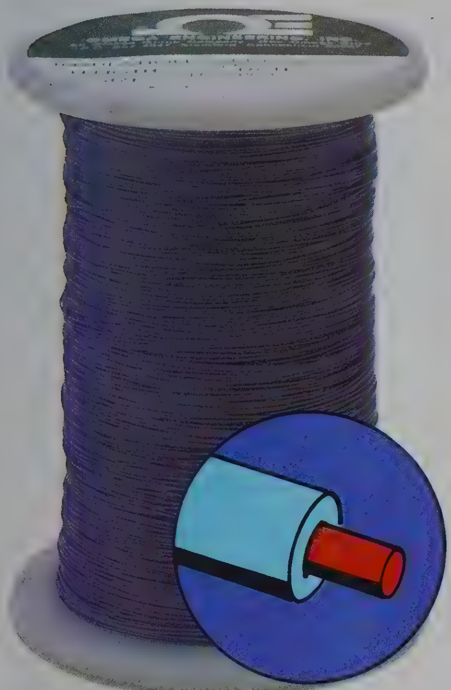
To Order

Specify SG1-Kit

$395

COMPARABLE VALUE IF PURCHASED SEPERATELY—$450

FINE GAGE .005" DIA. SINGLE WIRE



- 3 Mil Teflon Wall
- Single Strand
- Extruded PFA (Teflon)
- Excellent in Vacuum
- Non-flammable

OMEGA'S thin-wall covering process guarantees continuous lengths up to 1,000 feet. This wire is ideal for connecting the strain gages to solder terminal strips and pads.

Price Table	
Spool Size	**Price**
50 Ft. 100 Ft. 500 Ft.	**$11.00** **21.50** **85.00**

To Order *(Specify catalog number)*

Dia.	Length Ft.	Cat. No.	Price
.005	50	TFCP-005- 50	**$11.00**
.005	100	TFCP-005-100	**21.50**
.005	500	TFCP-005-500	**85.00**
.010	50	TFCP-010- 50	**11.00**
.010	100	TFCP-010-100	**21.50**
.010	500	TFCP-010-500	**85.00**
.015	50	TFCP-015- 50	**11.00**
.015	100	TFCP-015-100	**21.50**
.015	500	TFCP-015-500	**85.00**

MULTI-CONDUCTOR RIBBON CABLE

- 28 AWG Stranded Conductors
- PVC Rating to 105°C
- Color Coded
- 100 Foot Rolls

OMEGA'S ribbon cables are PVC preinsulated conductors laminated to a clear PVC film to allow easy termination. The color coding allows for quick identification and circuit tracing. The multi-conductor ribbon cable can be easily trimmed to any desired conductor width for different uses.

To Order *(Specify catalog number)*

No. of Cond.	Cat No.	Price 100 ft
4	RC- 4-100	**$ 42.00**
10	RC-10-100	**31.00**
14	RC-14-100	**44.00**
16	RC-16-100	**50.00**
26	RC-26-100	**81.00**
50	RC-50-100	**155.00**

All Wire Stocked For Immediate Delivery

MULTI-CONDUCTOR SHIELDED CABLE

- 24 AWG Tinned Copper Wires
- PVC Insulation
- Aluminum-Polyester Shield with #24 Drain Wire
- PVC Jacket Overall
- 100 Foot Rolls

Shielded cable provides the high conductivity and noise immunity required for instrumentation hook-ups to transducers. It is suitable for low and high level voltage signals and mA pick-up in high EMI/RFI environments.

To Order *(Specify catalog number)*

No. of Cond.	Nom. O.D.	Cat. No.	Price 100 ft.
4	.190"	TX- 4-100	**$28.50**
8	.220"	TX- 8-100	**43.50**
15	.280"	TX-15-100	**88.00**

CONVENIENT PRE-SPOOLED LENGTHS

OMEGA 880 DIGITAL MULTIMETER
88.0
OMEGA 881F DIGITAL MULTIMETER
88.1
DCA
TEMP
ACA
mA
COM
V-Ω
COM-500V MAX
TYPE K TC
NiCr-NiAl

Model 881F
$209
°F Display

Multimeters

Test Leads Included! Easy-to-use instruments to measure strain gage resistance, insulation resistance, bridge current and output voltages.

Carrying Case
$10
SC-800

Model 880
$134

MULTIMETER ACCURACY

	dc	dc	ac	ac	
	Voltage	Current	Voltage*	Current*	Resistance
Sensitivity:	100 μV	1 μA	100 μV	1 μA	100 mΩ
Model 880:	±(.25% rdg ±1 digit)	+(.75% rdg + 1 digit)	±(1% + 3 digits)	±(2% rdg + 2 digits)	±(0.5% rdg + 4 digits)
Model 881:	±(2.5% rdg +1 digit)	±(.75% rdg + 1 digit)	+(1% + 9 digits)	±(2% rdg + 9 digit)	±(0.5% rdg + 4 digits)

**TRMS with Model 881*

TEMPERATURE—MODEL 881

Model	Range	Resolution	Accuracy
881F	0 to +2000°F	1°F	+(5°F + 1 digit) up to 225°F
881C	−20 to +1370°C	1°C	+(3°C + 1 digit) up to 150°C

Notes: ±3 rdg over 225°F (150°C), chart correctable to 1.5% rdg over 600°F (300°C)

The OMEGA® Models 880 and 881 are fully portable Digital Multimeters designed with a rugged, high impact case to withstand daily field use. These precision DMM's measure dc voltage and current, ac voltage and current, and resistance. In addition, the Model 881 features TRMS ac voltage and current, and TEMPERATURE MEASUREMENT from a type K thermocouple. Both the Model 880 and 881 feature 0.25% accuracy, and the Model 881 is available with either °C or °F temperature display.

INCLUDED FREE:
Beaded Wire Thermocouple and Connector

How To Order

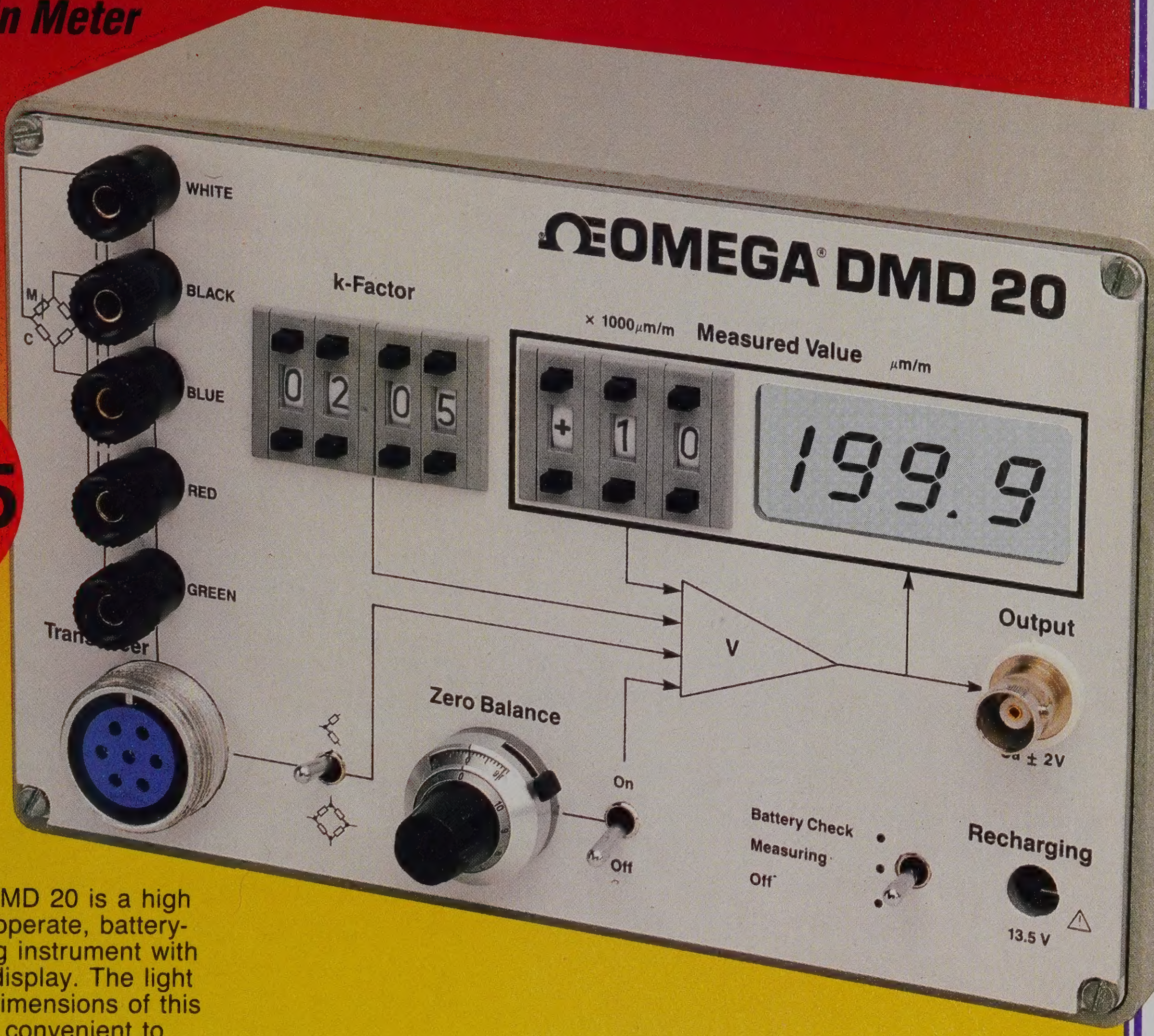
In Stock for Immediate Delivery

Model	AC	Temperature Range	Price
880	Average Responding	Current and Voltage Only	**$134**
881C	TRMS	−20 to 1370°C	**199**
881F	TRMS	0 to 2000°F	**209**

STRAIN GAGE INSTRUMENTS

Digital Strain Meter DMD 20

Batteries Included



Model DMD 20
$1,635

Portable Rugged Heavy Duty Case

The strain meter DMD 20 is a high accuracy, easy to operate, battery-powered measuring instrument with an integral digital display. The light weight and small dimensions of this instrument make it convenient to use. Strains and other mechanical quantities such as forces, pressures, etc., can be measured by the DMD 20 in conjunction with strain gages and strain gage transducers. The DMD 20 is designed for measuring static quantities. Low frequency phenomena of 15 Hz (−1 dB) or of 20 Hz (−3 dB) can however be recorded via an analog output signal. The measuring instrument operates with a carrier frequency of 225 Hz and ensures a high resolution with great accuracy of measurement and zero point stability. The transducer is supplied 1 V symmetrical about earth. To avoid cable effects, the transducers can be operated via a cable compensation circuit. When used with strain gages, strain can be directly displayed in "microstrain" units (μm/m or μin/in) by digitally presetting the gage factor (k).

Special features

- Accuracy class 0.025
- Battery-powered for mobile use
- Carrier frequency 225 Hz
- Full and half bridges can be connected with 60 Ω to 2000 Ω
- Large overall measuring range of ±20,999 μm/m
- Analog output for indicating range ±1999 μm/m
- Measuring frequency range 0 . . . 15 Hz (−1 dB)
- Low bridge excitation voltage of 1 V
- Digitally preset gage factor of 0.50 . . . 19.99
- Continuously adjustable zero balance ±1250 μm/m
- Cable compensation circuit to prevent cable effects
- Complete manual supplied

ALSO AVAILABLE
10 POSITION SWITCH
FOR THE DMD-20
SPECIFY MODEL DMD-10 $1,070

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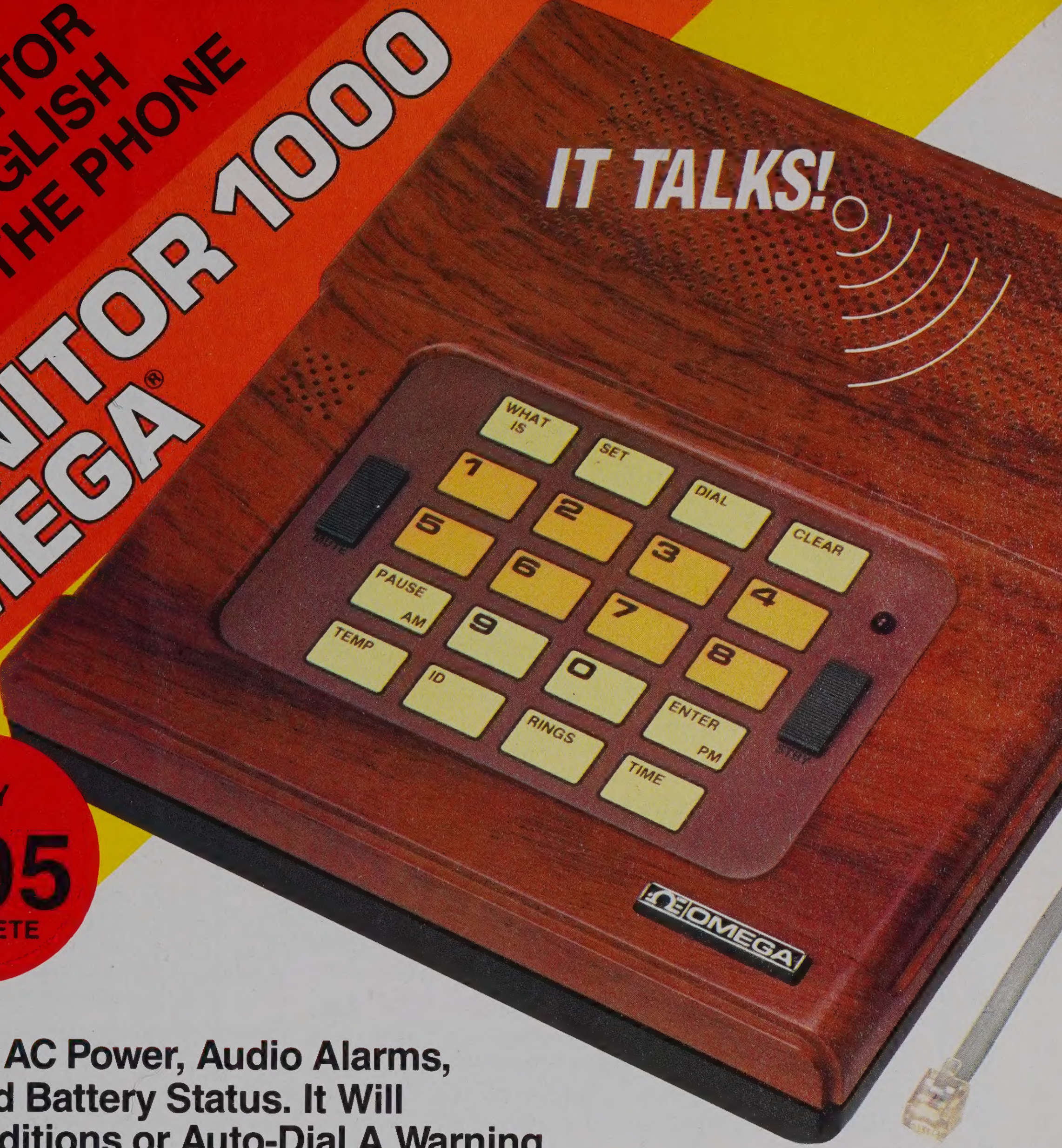
NEW!

TEMPERATURE AND ALARM MONITOR REPORTS IN ENGLISH ON-SITE & OVER THE PHONE

LAB MONITOR 1000

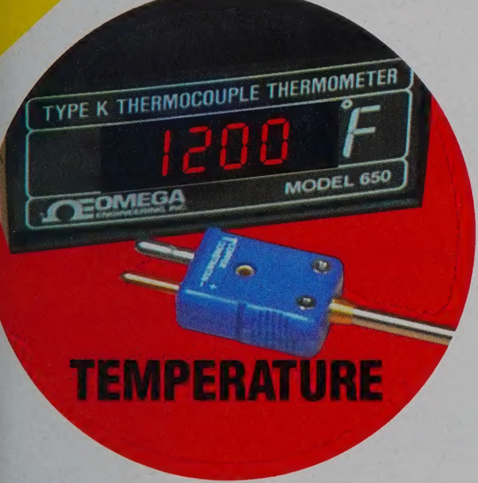
FROM OMEGA®


IT TALKS!
WHAT IS
SET
DIAL
CLEAR
1
2
3
4
5
6
7
8
9
0
PAUSE
AM
TEMP
ID
RINGS
ENTER
PM
TIME
MUTE
STBY
OMEGA

ONLY
$195
COMPLETE

Monitors
Time, Temperature, AC Power, Audio Alarms, Switch Contacts and Battery Status. It Will Report Current Conditions or Auto-Dial A Warning In The Case Of Alarm.

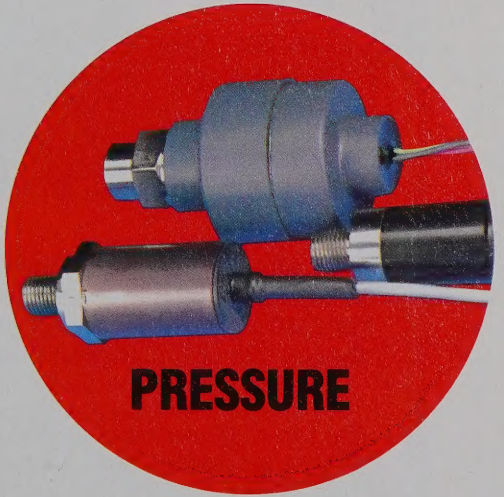
Plugs into any RJ-11C telephone jack


TYPE K THERMOCOUPLE THERMOMETER
1200 °F
MODEL 650
OMEGA

TEMPERATURE

PROCESS CONTROLLER
1500
OUT 1
OUT 2
RESET
MODE
OMEGA
PROCESS CONTROLLER
100
OUT 1
OUT 2
RESET
MODE
OMEGA

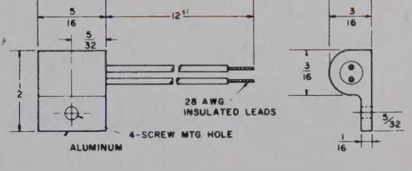
CONTROL STATUS



PRESSURE

REMOTE TEMPERATURE SENSOR LM-1003

$44


5/16
5/32
12"
2
28 AWG INSULATED LEADS
4-SCREW MTG. HOLE
ALUMINUM
3/16
3/16
5/32
1/16

OMEGA® 1984 PRESSURE AND STRAIN MEASUREMENT HANDBOOK™

HBM
OMEGALINE™ 600
ΩOMEGA
μMEGA
INTELLIGENT SCANNING SYSTEM
PROCESS CONTROLLER
246
OUT 1
OUT 2
RESET
MODE
PROCESS CONTROLLER
1072
PROCESS CONTROLLER
780
SIGNAL MONITOR
1492
OMEGA ENGINEERING MODEL 199E
PRESSURE MONITOR
OMEGA ENGINEERING MODEL DP350

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